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ABSTRACT

This project had two objectives: (1) to identify and structure concepts and generalizations basic to teaching foods and nutrition at the college level, and (2) to test the feasibility of using a small committee of experts to develop a statement of concepts and generalizations. Both objectives were accomplished but with stated limitations. Concepts, sub-concepts, and generalizations within a college-level foods and nutrition curriculum are structured under three major headings: Food Materials, Biological Aspects of Human Nutrition, and Human Behavior in Relation to Food. These materials were developed during approximately 11 days of conference by a committee of eight experts, supplemented by three coordinators and an educational consultant. Recommendations include (1) extension and refinement of these materials, and (2) the development of test situations for evaluating the use of concepts and generalizations as a basis for teaching. (Not available in hard copy due to marginal legibility of original document.) (CH)

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Final Report
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DETERMINATION OF CONCEPTS BASIC TO AN IMPROVED FOODS AND NUTRITION CURRICULUM AT THE COLLEGE LEVEL

June 1968

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DETERMINATION OF CONCEPTS BASIC TO AN IMPROVED FOODS AND NUTRITION CURRICULUM AT THE COLLEGE LEVEL

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Table of Contents

Page

ACKNOWLEDGMENTS ii

SUMMARY 1

INTRODUCTION 4

BACKGROUND 4

USE OF REPORT 5

METHODS 8

FINDINGS 14

CONCEPTS AND GENERALIZATIONS

FOOD MATERIALS 15

BIOLOGICAL ASPECTS OF HUMAN NUTRITION 79

HUMAN BEHAVIOR IN RELATION TO FOODS 98

DISCUSSION 117

EDUCATION CONSULTANT'S EVALUATION OF THE METHOD OF WORKING . . 120

CONCLUSIONS AND RECOMMENDATIONS 123

APPENDIX 125

DIRECTIONS FOR OUTSIDE REVIEWS 125

Acknowledgments

The present document represents the combined endeavors of a small group of faculty members who felt a deep concern for identifying the concepts and generalizations basic to teaching Foods and Nutrition in Home Economics. I should like to thank these dedicated persons--the Coordinators, the Education Consultant, and the members of the Guidance Committee for their support and contributions to the present undertaking. Each person has given much time, thought, and effort to this project and without such commitment the work could not have been accomplished. Appreciation is also expressed to the Foods and Nutrition specialists, outside the Committee, who reviewed preliminary drafts of the document and offered valuable suggestions; likewise thanks are extended to faculty members in a number of Departments of Food Science who examined the statements concerning FOOD MATERIALS to try to ascertain if, or wherein, duplication in content is suggested. Finally, the role played by the U.S. Office of Education is gratefully acknowledged. Only with the financial assistance provided by this agency could the work have been undertaken and brought to its present stage of development.

The section within the document entitled HUMAN BEHAVIOR IN RELATION TO FOOD deserves special comment. This section is uniquely the contribution of Dr. Marion Sweetman, currently Consultant, Department of Foods and Nutrition, University of Connecticut. With the approval of the Guidance Committee, material is presented for which she is sole author. One purpose of this section is to indicate the means by which a social science, in this case, primarily cultural anthropology, may be utilized in modern teaching of Foods and Nutrition. Development of concepts based on a similar integration between Foods and Nutrition and other social sciences, especially economics, would be equally appropriate and highly desirable.

Dorothy H. Strong

Summary

The prime objective of this study was to elucidate the basic concepts and supporting generalizations on which college and university teaching of Foods and Nutrition within the confines of Home Economics is structured. For one section (FOOD MATERIALS), limited efforts were directed toward ascertaining whether the concepts and generalizations accepted as basic were similar or different from those on which the teaching in a related department is based. At test, also, was the practicability of the procedure utilized for developing a statement of the concepts and generalizations.

To arrive at such a statement a Guidance Committee was formed, the members of which represented in addition to their subject matter specializations, different geographical areas of the United States. Auxiliary to the Committee were a Coordinator and two Associate Coordinators, each representing an area of specialization within Foods and Nutrition, and an Educational Consultant. The Committee decided on a basic outline of the material to be covered. Thereafter, the Coordinators were responsible for presenting statements of concepts, sub-concepts and generalizations to be scrutinized by Committee members and judged for inclusion, revision or rejection. When tentative agreement on the concepts, sub-concepts, and generalizations for a particular area was reached, opinion of outside "specialists"--e.g. other college or university teachers of Foods and Nutrition--was sought. Most frequently, the latter action was accomplished by Committee members consulting with colleagues at their institutions, but in some cases the Coordinator visited an institution for consultation.

Also considered was possible overlap between departments within a college or university in the development of a concept. The original plan had been to study this problem by conferences between the Coordinator and representatives of departments whose teaching was likely to impinge on Foods and Nutrition subject matter. Time did not permit this plan to be executed; however, one section of the report (FOOD MATERIALS) was submitted to six Food Science departmental chairmen with the objective of learning whether the same concepts and generalizations were developed in courses offered in their departments.

Because of the necessity for each Committee member to work in the area of his greatest specialization, the mode of operation during a limited part of the time in which the statement was developed was actually that of three subcommittees. The report reflects this procedure and the concepts, sub-conepts, and generalizations are presented in three sections: FOOD MATERIALS, BIOLOGICAL ASPECTS OF HUMAN NUTRITION, and

HUMAN BEHAVIOR IN RELATION TO FOOD. Understandably, the work progressed at different rates of speed and the reports have been brought to varying degrees of completion.

Early in the Committee negotiations, a definition for concept and generalization were agreed upon:

> Concept -- a key idea central to mastery of a field. Concepts are expressed by words or phrases.
>
> Generalization -- a complete thought that expresses an underlying truth, has an element of universality, and usually indicates relationships between or among concepts.

In the FOOD MATERIALS section, the major concepts are presented under the following headings: (I) Nature of food materials, (II) Major chemical components and their functional properties in foods, (III) Physical and physico-chemical systems present in plant and animal tissues and in processed and prepared foods, (IV) Processes and treatments employed to alter foods, (V) Influence of chemical composition and physical and physico-chemical systems of a food on the sensory properties, (VI) Potentially hazardous substances in food materials and their control, (VII) Processes and treatments used to extend the storage life of food materials, and (VIII) Changes in the nutritive value of foods during storage, processing, and preparation.

The major concepts related to BIOLOGICAL ASPECTS OF HUMAN NUTRITION are organized under the following topics: (I) Biological needs for nutrients, (II) Significance of nutrients in meeting biological needs, (III) Mechanisms through which nutrients meet biological needs, (IV) Nutrient requirements and standards, and (V) Food as sources of nutrients.

The organizational plan for HUMAN BEHAVIOR IN RELATION TO FOOD included four major sub-topics: (I) Human foodways--the uniformities and diversities of man's activities in the getting, selecting, manipulating, and eating of food, (II) The origin and development of human foodways, (III) Individuality in food behavior, and (IV) Food behavior and human well-being.

While the reviews of the preliminary statement of concepts and generalizations undertaken by specialists within the field of Home Economics indicated general concurrence with the plan and organization of the document, suggestions were made concerning the accuracy, revisions, and inclusion of individual statements.

An attempt was made to secure a judgment concerning the relative importance of each statement in the conceptual framework of Foods and Nutrition curricula, at the college level, by asking the specialists to indicate the course at their institution in which the development of a concept was emphasized. This approach failed to yield significant information.

The review of the FOOD MATERIALS section by faculty members in six Food Science departments indicated a high degree of duplication in the concepts considered important to a mastery of the field but suggested differences in emphasis and approach in their development. This result suggests the need to evaluate the extent to which courses in Food Science may be offered that serve the needs of students within Home Economics and in related areas. It was deemed to be desirable to review nutrition teaching from this viewpoint also.

Since the procedure utilized in elucidating the Foods and Nutrition concepts, based as it was on the action of a small committee plus supporting personnel, was an innovation, some comments concerning its feasibility are included here. Unfortunately, there was no control group, so only general statements are possible.

To the extent that a statement of concepts, sub-concepts,and generalizations for the area of Foods and Nutrition has been compiled, the method succeeded. The Committee spent over-all only 11 days in conference; thus, the procedure may be helpful for groups in which qualified personnel find it difficult to be absent from their usual professional commitments. Limitations in the method included production of a final document which is more complete for certain areas than for others, inadequate time for full committee action and for large involvement of persons outside the committee membership. With the experience gained from this effort, it would seem possible to set up a plan similar to the one used here, which would be feasible and would produce satisfactory results.

Introduction

In recent studies a technique utilized with some success for the improvement of teaching, has been the elucidation of the concepts basic to understanding within a given academic discipline. Through this device efforts have been made to better organize and integrate specialized knowledge for presentation to students.

The present document constitutes initial -and incomplete -efforts in a similar direction for college or university teaching in Foods and Nutrition, when structured within the framework of Home Economics. In the report are presented statements of concepts and, to a more limited extent, generalizations--a reasonable mastery of which might be expected of all persons having completed a Bachelor's degree with a major in this field. It is not the presumption of those who developed these statements that the identification of or learnings concerning all of the concepts shall occur either in Foods and Nutrition courses or in courses offered within Home Economics.

The content of the report is organized in three sections, each of which assumes a background in one or more of the basic disciplines: FOOD MATERIALS, which requires a foundation in chemistry, microbiology, and physics; BIOLOGICAL ASPECTS OF HUMAN NUTRITION, which requires a foundation in biochemistry and human physiology or zoology; and HUMAN BEHAVIOR IN RELATION TO FOOD, which requires a foundation in the social (behavioral) sciences.

Background

The field of Foods and Nutrition has, from the beginning, been included as a part of the course offerings in Departments, Schools or Colleges of Home Economics. This field sits astride the more basic disciplines of chemistry, including biochemistry, organic and physical chemistry, and physiology, and bacteriology. It has recognized also the influence of socio-cultural, psychological, economic and aesthetic factors on human behavior in relation to food, and so to nutritional well-being. The line of demarcation between teaching presented in certain of the natural sciences and in Foods and Nutrition has not always been clear; in addition, further complication has arisen with the development of departments of food science and with the interest of some social scientists in the relationship of food to cultural and behavioral patterns. This situation has great merit but places on teachers of Foods and Nutrition the necessity for understanding as definitively as possible, their role in the education of the student--a role which may vary under different institutional organizations.

The present work had its origin in an effort made some years ago by a selected group of Home Economists, to define the concepts basic to each area encompassed in the general field. Progress for the Foods and Nutrition field was slow in this regard because of limitations of time for such a study on the part of qualified personnel, although the results of some earlier efforts have been recorded (1), (2) (3), and (4). At a 1965 meeting of representation of this field it was decided to seek funding and to utilize a somewhat different technique as a means of identification of the basic concepts for this area of specialization, in an endeavor to spped the work. Other groups have worked toward similar goals by maintaining conference-discussions among representatives of the discipline over considerable periods of time. The methodology adopted for the present study is described in the section of the report prepared by the Educational Consultant.

USE OF REPORT

It should be emphasized that the membership of the Committee who have worked on this project regard this report as an initial step in the identification of concepts, and, to a considerable extent, to be unfinished. The report is obviously incomplete in the sense that certain important approaches to the study of Foods and Nutrition have only been suggested and have not been fully developed. Economic and managerial aspects for example, are among those areas which have been least adequately covered and certain of the nutrition concepts are presented without the supporting generalizations. It is unfortunate that parts of the work did not come to the full fruition originally envisioned by the Committee.

While reluctant to release a statement which perhaps has limitations in accuracy as well as the limitations in scope indicated above, the Committee believes the report should be made generally available. Following are some suggested ways in which the report might be used:

. as a basis for discussions and testing by educators responsible for curriculum development in this field, with the objective of reaching some consensus concerning the content considered necessary to a mastery of the field by baccalaureate candidates with a major in food and nutrition.

. as a basis for discussions by educators responsible for instruction in this field with the objective of refining the statements, and for experimentation with different methods of presentation of content to test their effectiveness in developing an understanding of the concepts and generalizations (in contrast to an accumulation of facts that have not been integrated into a meaningful body of knowledge).

. as a basis for research, including graduate student thesis research designed to validate the individual items as concepts or generalizations.

- by the teacher as a means of assisting him in selecting that which is pertinent and appropriate for his course offerings.

Few specific facts, and little of the descriptive materials, which would be included in instruction designed to develop the concepts and generalizations, are included in this report. Recognizing that a statement of concepts in broad terms is of limited value as a guide for curriculum development and instruction, an attempt has been made to develop the broad concepts into sub-concepts and generalizations and to suggest some applications. At no time, however, should the material herein presented by considered to be lesson plans or the subject matter which should be taught. Rather it is intended to be the framework from which plans for teaching will evolve. It should be pointed out that although the material has been organized in a meaningful order, other organizations might have been used, and many different programs should be effective in developing a mastery of the suggested content.

The emphases and applications indicated suggest that much of the content would be presented only in an institutional unit concerned with the utilization of food to provide adequate nutrition for man--a concern for man's biological needs for nutrients; the availability safety, and acceptability of food as a source of those nutrients; and the social-psychological, economic and managerial aspects of feeding individuals and population groups.

To be of greatest value to the profession, steps should be taken to develop an improved statement and plans should be made to provide for continuous review and revision of the statement. Although college and university personnel have major responsibility for curriculum development and for instruction, members of the various professions which look to these institutions for their professional personnel should participate in these activities. As a second step, experimentation in approaches to course organization and classroom teaching should be initiated designed to develop the proposed concepts as well as to provide a mastery of the pertinent subject matter.

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1. Anonymous, *Home Economics Seminar* - A Progress Report, French Lick, Indiana, 1961.

2. Hill, Mary M., *Basic Nutrition Concepts - Their Use in Program Planning and Evaluation.* Nutrition Program News, U.S.D.A., November - December, 1964.

3. Todhunter, E. Neige, *The Evolution of Nutrition Concepts--Perspective and New Horizons.* Journal of The American Dietetic Association 46: 120-28, 1965.

4. American Home Economics Association, *Concepts and Generalization: Their Place in High School Home Economics Curriculum Development*, 1967.

Methods

REPORT OF THE EDUCATION CONSULTANT

Bernadine H. Peterson

The report of the 1961 French Lick Home Economics Seminar identified an important underlying issue facing those responsible for determining roles and contributions of educational programs in the university setting. It stated:

> All programs of education at all levels face the insistent need for self-examination and reappraisal of their roles and their contributions to education in a rapidly changing social and world order. In the light of changes in the educational scene, it becomes increasingly evident that only those disciplines which have emerged as mature well-defined fields of knowledge and which have kept abreast of and become involved in,current educational progress and developments, will endure in the university setting.[1]

Thus it seemed urgent to participants at the Seminar that immediate attention be given to identifying the basic content of the several areas of Home Economics in order that the broad field itself could be clearly defined.

It was decided that the first step would be to delineate the cognitive content of the field through key concepts and principles pertinent to and significant in each of its subject matter segments. Dressel suggested to Seminar participants that concepts include "the cognitive aspect of the curriculum as it is embraced in significant ideas inclusive of definitions, generalizations, principles, and unifying or integrative words or phrases."[2] Seminar participants judged the concept approach worth pursuing.[3]

Among the participants at the Seminar were representatives of several national and regional groups of college teachers, including those in Foods and Nutrition. These representatives expressed interest in continuing work on the concept approach within their group. It was suggested that:

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[1] Anonymous, Home Economics Seminar, A Progress Report. French Lick, Indiana, 1961, p. 19.

[2] Paul Dressel "The Role of Concepts in Planning the Home Economics Curriculum" Home Economics Seminar, A Progress Report. French Lick, Indiana, 1961, p. 11.

[3] Anonymous, Home Economics Seminar, op cit., p. 39.

> (1) the usefulness of the concept approach be further explored through national and regional program projects; (2) the participants who attended this Seminar be the coordinating group for unifying efforts for next steps; (3) the subject matter specialists should be the group to assume active responsibility for implementing the beginning efforts of the Seminar.[4]

A committee designated as the Interim Committee of the Association of Land-Grant Colleges and Universities was charged with forwarding the work of determining the concepts unique and basic to Home Economics teaching. A group of eight people concerned with meeting this responsibility for the Foods and Nutrition area met in Chicago in March 1965. Included were a limited number of participants from the French Lick Seminar but most of the personnel had not been present at the earlier Seminar. The group reviewed the work which had been done at the French Lick Seminar, noting particularly the recommendation:

> The conclusion that the concept approach to restudy of the home economics curriculum should be further pursued raises some questions as to how this should be done. Clearly, the task is not one which a large number of persons can work together upon effectively and solve in a short period. Rather, a limited number of individuals will need to work over a long period of time to identify concepts and principles, develop new curricular materials, and arrange for experimentation with them. The experiences of some other groups earlier mentioned should be consulted. The task--as the experiences of these groups have shown--is not easy, but it should be highly rewarding.[5]

The group decided that the problem presented could most effectively and efficiently be met by initiating a research study, funds for which would be sought and would be placed at a single University. It was further decided that the work would be planned and supervised by a Guidance Committee made up of eight college or university Foods and Nutrition faculty members, to be drawn from four geographical areas within the United States; that a senior faculty member at the institution initiating the request for research support would serve as project director; that a professional person in curriculum development, also from the initiating institution, would serve as a educational consultant for the project and that a successful college Foods and Nutrition teacher would serve on a half-time basis as a coordinator for the project.

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[4] Ibid., p. 41.

[5] Ibid., p. 39.

The coordinators' prime responsibility was designated as the development of statements of the concepts, sub-concepts, and generalizations basic to the college teaching of Foods and Nutrition. The proposals developed by the coordinator were then to be submitted at meetings of the Guidance Committee for review, criticism, and, if necessary, restatement. Plans were made for four Guidance Committee meetings to occur at intervals of about four months. It was anticipated that in about 18 months time a consensus could be reached and a report drawn.

A further part of the original plan included visits by a Coordinator and a Committee member to a number of institutions, for the purpose of discussion and review of the proposed statements of concepts, sub-concepts, and generalizations with faculty members both in Home Economics and in related basic disciplines. Only after this had been accomplished, would the final report be drawn.

The most unusual feature of this arrangement was the method suggested for carrying out the work. Usually a committee works together for substantial periods of time to carry out a responsibility such as was undertaken in this project. The method here proposed was an attempt to expedite work which was urgently needed but hindered by the inability of qualified personnel to be freed from other commitments and to delegate time to accomplish the task.

Certain modifications of the original plan became necessary. For various reasons some readjustment of personnel was required. The Guidance Committee finally committed to the project included ten members (eight members from the various geographical areas, one of whom also served as an Associate Coordinator, two members from the original French Lick Seminar), one Coordinator and one additional Associate Coordinator plus the Education Consultant. The University of Wisconsin became the initiating institution.

The change which involved appointment of a Coordinator and two Associate Coordinators rather than a single coordinator was made by the Committee to permit those having greatest specialization of knowledge to be charged with writing the original statements of concepts and generalizations. Because of subject matter specialties and interests of the members, the Committee at times divided itself into three sub-committees, as it worked toward the objectives of elucidating the concepts and generalizations. The Coordinator or one Associate Coordinator worked with each of the sub-committees. The subdivision within the total field of Foods and Nutrition were identified as FOOD MATERIALS, BIOLOGICAL ASPECTS OF HUMAN NUTRITION, and HUMAN BEHAVIOR IN RELATION TO FOOD.

A workshop held at Cornell University and sponsored by the Home Economics Branch of the U.S. Office of Education, during the summer of 1963, to develop concepts basic to Foods and Nutrition at the secondary level, resulted in materials which were made available to the Foods and Nutrition Committee by Dr. Berenice Mallory. (These were subsequently published/47/). These materials were reviewed and were found to be helpful.

The first meeting of the Committee was an organizational one. The Education Consultant met with the Committee to present background information on concepts and generalizations and their usefulness in curriculum development. Preliminary plans were made for a method of working. Definitions for the terms "concept" and "generalization" were accepted. These are included later in this report.

At the second meeting an outline for the projected materials was discussed and preliminary work from two areas, FOOD MATERIALS and HUMAN BEHAVIOR IN RELATION TO FOOD, presented by the Coordinator and Associate Coordinator was reviewed by the Committee. Since the Committee sought to assess the scope of the field and to identify structure, this part of the project in itself took time at the first two meetings. It was at the second meeting that the outline which served to give direction for the work was finally established.

At the third meeting materials from the first two areas were revised and refined and the review of the third area, BIOLOGICAL ASPECTS OF HUMAN NUTRITION, was begun. At the fourth meeting additional review, with revisions and editing were undertaken and final plans for publication were decided.

Throughout the working period critical evaluation of materials by "specialists" outside the Committee was sought. These "specialists" were usually college or university teachers, most frequently located at the home institution of the Committee members. In a limited number of instances, concurrent with review by the specialists was a visit to the particular institution by the Coordinator and a Committee member for the purpose of consultation. During the visit something was learned about how the teaching of Foods and Nutrition was organized in each institution and whether problems of overlap with units other than Home Economics might exist. These latter activities were carried out to a considerably lesser degree than was originally planned by the Committee because the Committee was unwilling to ask outside reviews of an incomplete document.

A check sheet for use by the specialists in their review was developed by the Guidance Committee. Reviewers were asked to indicate for each item: (1) their judgment of its relative importance in a curriculum for Foods and Nutrition majors in Home Economics at the Bachelor's level and (2) if the concept or generalization is developed in the course(s) they teach, and if not, in some course available in the university. They were also asked to suggest significant concepts or generalizations that they believed should be added to the statements and were given opportunity to comment if they questioned the accuracy or wording of any item. A form for recording this information was provided. Subsequent revisions were made in view of these evaluations.

The Education Consultant worked with the Committee for a portion of the time at each of the meetings. She served in an advisory capacity. reacting to the educational aspects of materials developed. She was frequently asked to criticize materials that had been developed, and made suggestions for wording of materials to meet the educational criteria developed earlier. She observed the method of working utilized by the Committee, since one of her functions was to evaluate the effectiveness of the method in developing curriculum materials.

It will be obvious from the results that the three areas, BIOLOGICAL ASPECTS OF HUMAN NUTRITION, FOOD MATERIALS, and HUMAN BEHAVIOR IN RELATION TO FOOD. did not develop uniformly which in part explains the limitation in the planned visits to the several institutions. The FOOD MATERIALS section is the most complete. This section was reviewed by nine specialists in Foods and Nutrition--Home Economics and by members of six Food Science Departments. For the BIOLOGICAL ASPECTS OF HUMAN NUTRITION section, evaluation was made by a few Nutrition specialists in Home Economics. This section is not complete and must be interpreted as a progress report only; some attempt has been made to identify remaining concepts that should be included but it has not been possible to include generalizations for all concepts.

Concepts and generalizations in HUMAN BEHAVIOR IN RELATION TO FOOD were reviewed by Food and Nutrition specialists at four institutions and by a Social Scientist at two. These materials are presented as an example of a kind of integration of Social Science and Foods and Nutrition that has received increasing emphasis in recent years. The Committee felt they should be included in the report but recognized that the materials do not cover all aspects of the Social Sciences which should be included in curricula for Home Economics students specializing in the area of Foods and Nutrition.

The statements of concepts and generalization presented in this report have evolved through the process of: (1) preparation of a draft by an individual specialist, (2) review by the Guidance Committee, (3) review by additional specialists, and (4) appropriate revisions based on their proposals.

Concepts and Generalizations -- Definitions and Context

Since the terms "concept" and "generalization" are used in various ways in curriculum materials, it is important to clarify these terms as they are used in this report. Definitions agreed upon by the Committee are:

Concept - a key idea central to mastery of a field. Concepts are expressed by words or phrases. Examples of concepts included in this report are : "Dynamic state of all tissues" (from section on BIOLOGICAL ASPECTS OF HUMAN NUTRITION); "Multi-phase systems in food materials" (from FOOD MATERIALS section); "Societal patterning of food manipulation" (from section on HUMAN BEHAVIOR IN RELATION TO FOOD).

Generalization - a complete thought that expresses an underlying truth, has an element of universality, and usually indicates relationships between or among concepts. Examples of generalizations included in this report are: "Interactions between or among minerals may enhance or inhibit their effectiveness and so affect the dietary intake required for the nutrient"; "The flavor of raw fruits is determined largely by their content of sugars, acids, various volatile organic compounds, and polyphenolic compounds"; and "The conditions of crystallization significantly affect the size of the crystals formed".

The concept approach to curriculum organization permits the teacher to reduce the complexity of the environment for students because it guides him in selecting for major emphasis the basic ideas in his field. Thus, the capacity to learn can be most efficiently and effectively utilized. Concepts permit him to relate learning to previous learning. Concepts permit the student to predict into the future and anticipate and meet new situations, since they give a structural framework to learning.

In many cases, generalizations presented in this report are quite detailed and examples are frequently given of the idea presented. The Guidance Committee felt that these practices could make these materials readily usable. Difficulty in using the high school materials developed earlier has been a serious problem for teachers.

Findings

This report presents a statement of concepts and generalizations in three areas of the field of Foods and Nutrition. The document as accepted by the Guidance Committee represents, for the areas covered the basic content appropriate to curricula in Foods and Nutrition for all candidates for the baccalaureate degree with a concentration in this field of Home Economics. The document reflects current knowledge based on research. It is considered to be preliminary and recognized to be incomplete both in scope and in content. The statements should be viewed as contemporary and need to be under continuous review and revision. Additions, deletions, and refinements should be made as the findings of research and the understandings gained through observation and experience expand the boundaries of knowledge.

Three areas are included in the statement of concepts and generalizations:

FOOD MATERIALS

BIOLOGICAL ASPECTS OF HUMAN NUTRITION

HUMAN BEHAVIOR IN RELATION TO FOOD

For each section, an outline showing major concepts and sub-concepts is presented; this is followed by the detailed statement which includes the generalization.

FOOD MATERIALS

This section of the statement of concepts and generalizations for the field of Foods and Nutrition was subjected to several types of review which were not conducted with the other two sections, or were conducted on a more limited scale. A larger number of "outside specialists", both from within Home Economics and from a related discipline participated in evaluation of preliminary drafts. This procedure was especially valuable in indicating modifications that would improve the experimental method.

FOOD MATERIALS - OUTLINE

I. Nature of Food Materials.

  A. Complex nature of most foods.

  B. Variability of most food materials.

  C. Significance of chemical composition and physical properties of food materials. (See II, III, V, and VI.)

  D. Significance of toxic substances and of pathogenic microorganisms in food. (See VI.)

II. Major Chemical Components and Their Functional Properties in Foods. (See III and V.)

  A. Proteins and their properties of significance in food processing, preparation, and storage. (See II J, Enzymes.)

  B. Carbohydrates - Sugars and their properties, other than sweetening, of significance in food processing, preparation, and storage.

  C. Carbohydrates - Starches and their properties of significance in food processing, preparation, and storage.

  D. Carbohydrates - Cellulose and its role in food processing and preparation.

  E. Carbohydrates - Pectins and other complex hetero-polysaccharides and their properties of significance in food processing and preparation.

  F. Lipids - Fats and their properties of significance in food processing, preparation, and storage.

  G. Lipids - Phospholipids and Lipoproteins and their properties of significance in food processing, preparation, and storage.

  H. Pigments and their properties of significance in food processing, preparation, and storage. (See V B.)

  I. Intentional Chemical Additives and their properties of significance in food processing, preparation, and storage. (See III --- VIII.)

  J. Enzymes and their role in food processing and preparation.

K. Water and its properties of significance in food processing and preparation.

III. Physical and Physico-chemical Systems Present in Plant and Animal Tissues and in Processed and Prepared Foods. (See II, IV, and V.)

A. Single-component, single-phase systems in food materials.

B. Multi-component, single-phase systems in food materials.

C. Multi-phase systems in food materials.

D. Colligative properties of solutions and some properties of pure liquids.

E. Crystallization of pure liquids or from solution.

IV. Processes and Treatments Employed to Alter Foods.

A. Production of raw food materials.

B. Physical processes and chemical treatments used in food processing and preparation.

C. Transmission of heat to or from, or production of heat in, a food or food material.

D. Control of alterations in food materials.

V. Influence of Chemical Composition and Physical and Physico-chemical Systems of a Food on the Sensory Properties. (See II and III.)

A. Sensory qualities and palatability.

B. Influence of the components and systems present on the color of food.

C. Influence of the components of a food on its flavor.

D. Influence of physical states and physico-chemical systems on the texture of a food.

VI. Potentially Hazardous Substances in Food Materials and Their Control.

A. Types of hazardous substances that limit the usefulness of foods in human diets.

B. Poisonous substances in food materials.

C. Infectious micro-organisms and parasites in food materials.

D. Control of hazardous substances in food materials.

VII. Processes and Treatments Used to Extend the Storage Life of Food Materials.

A. Control of enzyme catalyzed reactions. (See II J.)

B. Control of microbial decomposition.

C. Control of undesirable chemical reactions.

D. Control of undesirable physical and physico-chemical changes.

VIII. Changes in the Nutritive Value of Foods during Storage, Processing, and Preparation.

A. Enhancement of nutritive value.

B. Lowering of nutritive value.

FOOD MATERIALS

All changes that occur in foods and food mixtures during processing, preparation, and storage are the result of physical or physico-chemical modifications or of chemical reactions in which the principle of cause and effect is operative. Reliable methods of controlling the changes take into account (1) the significant chemical components and physical and physico-chemical systems present and their properties, (2) the physical processes and chemical treatments that will bring about changes in these components and systems, and (3) the basic principles applicable to the components and systems and to the processes and treatments involved.

I. Nature of Food Materials.

A. Complex nature of most food materials.

1. Few food materials are single chemical compounds. Examples include sodium bicarbonate, sodium chloride, and sucrose.

2. Most foods are complex systems composed of many chemical compounds and frequently of more than one physical state and system. (See II and III.)

3. Many foods are unstable systems.

3.1. Some foods are biological materials containing metabolically active cells.

3.2. Other foods are mixtures of chemical compounds that can react with each other or with components of the environment, the reaction rates being time-temperature dependent.

B. Variability of most food materials.

1. Food materials that are a single compound are, when pure, of constant chemical composition (e.g. sodium chloride and sucrose).

2. Animals and plants, the usual natural sources of complex food materials, exhibit variability in structure and composition.

2.1. Inspite of their variability, food materials can be grouped into classes with common properties.

3. The variety possible in processed and fabricated foods is

infinite because of the diversity of available food materials and the processes and treatments that can be employed to alter them.

C. Significance of chemical composition and physical properties of food materials. (See II, III, V, and VI.)

1. The chemical composition (e.g. content of proteins, carbohydrates, lipids, and minerals) and the physical properties (e.g. molecular size and conformation, solubility, vapor pressure, and surface tension) of a food material play an important role in determining:

    - its acceptability.
    - its functional properties and so its potential in food processing and preparation.*
    - the conditions required to maintain its wholesomeness and integrity.
    - its nutritive value.

2. Complex food materials neither perform nor respond to manipulation in the same manner as simple model systems of their components because of their heterogeneous chemical composition and their organization (e.g. into cells, tissues, and organs).

    2.1. Inspite of these limitations, model systems are frequently useful in studying food components and their interactions to illuminate the properties of foods.

D. Significance of toxic substances and of pathogenic microorganisms in food. (See VI.)

1. The presence of a toxic substance or of pathogenic microorganisms will limit the usefulness of a food in human diets.

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* Processing - industrial treatments for preservation, modification of properties, or preparation of a food.

Preparation - home or commercial (institutional) treatments to make foods ready for consumption by the ultimate consumer.

II. Major Chemical Components and Their Functional Properties in Foods. (See III and V.)

A. Proteins and their properties of significance in food processing, preparation, and storage. (See II J, Enzymes.)

1. The chemical nature and physical conformation of protein molecules make this component of foods useful in determining their physical characteristics (e.g. viscosity, gel structure, foam formation, and emulsion stability).

1.1. The conformation of a protein molecule in the native state is determined by:

- the primary structure which consists of a characteristic number, kind and sequence of amino acids joined by covalent peptide bonds.
- a secondary structure, stabilized primarily by hydrogen bonds between amide hydrogens and carbonyl groups that causes coiling of the primary peptide chain (e.g. to form a helix or a pleated sheet).
- a tertiary structure, which causes folding of the coiled chain(s) and influences the degree of hydration, which results from interactions among the exposed amino-acid side chains. (The side chains are characteristic for each amino acid residue in the protein molecule.)

1.1.1. In addition to covalent and hydrogen bonds, ionic bridges, hydrophobic bonding disulfide linkages, and van der Waals forces may be involved in the structural organization of complex protein molecules.

1.2. Breakdown of the primary structure of a protein molecule results in the formation of simpler compounds and produces changes in solubility, degree of hydration, viscosity, and other properties.

1.2.1. Conditions that cause this breakdown are an environment conducive to enzymatic action and intense heat.

1.3. Intramolecular alternations in the secondary and tertiary conformation of a protein molecule (often described by the general term "denaturation") usually result in changes in its solubility and in the alteration of other properties because of the exposure of many of the functional groups of the protein.

1.3.1. Denaturation of a protein molecule may be produced by many physical and chemical treatments. These include:

- the addition of heat.
- a change in hydration (e.g. addition of sodium chloride).
- a change in the electrostatic state (e.g. change in the ionic environment due to the addition of an acid, base, or salt).
- physical treatments that cause orientation at a surface or interface (e.g. beating and kneading).

1.3.2. The changes and alterations produced are generally irreversible.

2. Denaturation of a protein in dispersion is frequently followed by intermolecular reactions, involving linkages between the exposed amino-acid side chains to produce a quaternary structural organization, that result in an aggregation of the molecules.

2.1. The physical state resulting from the coagulation of a protein dispersion is determined by the degree of aggregation and the hydration of the aggregates.

2.1.1. Typical examples of physical states resulting from the coagulation of protein dispersions are:

- a perceptible increase in the viscosity of the dispersion (e.g. soft egg custard).
- gel formation (e.g. rennet - milk gels).
- foam stability (e.g. egg white foam).
- syneresis (e.g. loss of juice from well-done beef muscle tissue).
- precipitation of the protein (e.g. curdled egg custard or milk).

3. Proteins in an aqueous dispersion have a surface-tension depressor effect and so tend to foam when agitated (e.g. egg white and skimmilk).

3.1. Surface denaturation of the protein, or other conditions that contribute rigidity to the foam structure, are essential for the production of a stable foam.

4. Some protein molecules, because they contain both hydrophilic (i.e. polar) and lipophilic (i.e. non-polar) groups tend to concentrate at an oil-water interface with the result that they are effective emulsifying agents (e.g. lipoproteins of egg yolk).

5. The chemical treatments and physical manipulations required to produce similar changes in the physical state of protein dispersions are specific for each protein (e.g. heat coagulation of lactalbumen vs that of casien, and coagulation of egg white proteins by mechanical agitation).

5.1. The kind, and within limits the amount, of protein in a plant or animal food material help to account for the differences in their uses and treatments in food processing and preparation.

5.1.1. Proteins vary in chemical composition and molecular conformation and are characteristic for a given source (e.g. casein and lactalbumen of milk, ovalbumen and lecithoproteins of egg, gliaden and glutenin of wheat, and actin, moysin and collagen of meat).

B. Carbohydrates - Sugars and their properties, other than sweetening, of significance in food processing, preparation, and storage.

1. Monosaccharides are the basic units of all more complex carbohydrates (e.g. starches, cellulose, and pectins) and are produced in green plants by photosynthesis.

1.1. The process of photosynthesis involves light absorption from the sun by chlorophyll to provide energy to a series of enzyme-catalyzed chemical reactions which yield the simple sugars and their polymers.

2. The chemical nature and physical properties of sugars determine:

- the usefulness of these food materials in controlling the viscosity and various colligative properties (e.g. boiling and freezing points and osmotic pressure) of their aqueous solutions.
- their role in browning reactions.

- a variety of interactions with other components of food mixtures (e.g. proteins, starches, and yeast) that influence consistency or texture of food products.

2.1. The relative effectiveness of various sugars in increasing the viscosity, boiling point, and osmotic pressure and in lowering the freezing point of their aqueous solutions is determined largely by differences in their solubility (e.g. lactose vs sucrose) and in their molecular weights (e.g. monosaccharides vs disaccharides). (See III D.)

2.2. Sugars (e.g. sucrose) that can form highly supersaturated solutions can be manipulated to yield crystals of a desired size and so to produce crystalline products of smooth or grainy texture. (See III E.)

2.3. Reducing sugars (e.g. glucose and lactose) react with amino groups (e.g. in proteins) to produce brown pigments (i.e. non-enzymatic browning).

    2.3.1. Factors affecting the browning reaction rate are temperature, pH, and moisture content.

2.4. Pyrolysis of sugars (i.e. caramelization) produces compounds that are brown in color, less sweet than the original sugars, and bitter.

    2.4.1. Factors affecting the caramelization reaction are temperature and pH.

    2.4.2. Monosaccharides are more susceptible to caramelization than dissaccharides.

2.5. Sugars, being polyhydric alcohol compounds, participate in molecular associations by hydrogen bonding. Their affinity for water is a significant factor in many food mixtures (e.g. starch and protein dispersions).

C. Carbohydrates - Starches and their properties of significance in food processing, preparation, and storage.

1. The chemical nature and physical structure of starch granules make this component of foods useful in increasing the viscosity of liquids and, frequently, in producing a gel structure. (Gels produced from the starch of wheat flour form a primary structure in baked products.)

1.1. The functional properties of native starches are related to the proportion of amylose and amylopectin molecules present, their molecular weights, their arrangement in granules, and the extent of intra- and inter-molecular bonding.

  1.1.1. The chemical composition and size and shape of the granules vary and are characteristic for a given source (e.g. corn, potato, wheat).

  1.1.2. The percentage of amylose and of amylopectin in different strains of a particular starch source may vary due to genetic differences (e.g. waxy corn and rice starches).

1.2. Amylose molecules (i.e. glucose units joined in a linear structure and coiled in an α-helix) tend to form intra- and inter-molecular linkages by hydrogen bonding with each other and with the linear sections of amylopectin molecules to produce crystalline micelles. These give rigidity to the native starch granule structure, resist hydration, and provide gel-forming properties to starch dispersions.

  1.2.1. Amylose molecules are conducive to retrogradation of starch gels on aging.

1.3. Amylopectin molecules (i.e. glucose units joined in a branched structure) provide an amorphous granule structure that permits a high degree of granule hydration and swelling to produce starch dispersions of high relative viscosity.

  1.3.1. Amylopectin molecules resist retrogradation in starch pastes.

2. The chemical nature of starch molecules can be altered by chemical reactions (e.g. use of phosphates in preparation of modified waxy corn starches), which modify the functional properties of the starch granules and adapt the starch for special uses.

3. On hydrolysis, starch molecules yield progressively smaller molecules (i.e. dextrins, maltose, and glucose) which lack the gel-forming properties of starch and form dispersions or solutions of lower viscosity.

  3.1. The rate of starch hydrolysis is accelerated by heat, extremes in low pH, and enzymes (e.g. amylases).

4. Breaking of the intra- and inter-molecular bonds decreases the rigidity of a starch granule and exposes polar groups.

    4.1. Heat (i.e. a high temperature or long exposure) and certain chemical treatments (e.g. high and low pH) favor the rupture of the intra- and inter-molecular bonds within native starch granules.

5. In an aqueous dispersion, the initial result of starch granule hydration is swelling of the granule and decreased rigidity.

6. Treatments that cause starch granules to swell tend to increase the viscosity of a starch dispersion, the relative viscosity increasing with increased granule size.

    6.1. If the amount of water available in a starch dispersion for hydration of the granules is limited, maximum swelling of the granules cannot be attained (e.g. in most baked products).

    6.2. The presence of sugars, because of their competition for water, and the presence of certain additives (e.g. mono-diglycerides that form complexes with amylose) tend to limit the hydration of starch granules and, therefore, the viscosity of starch dispersions and the strength of starch gels is limited (e.g. in sweetened baked products).

7. Swollen starch granules are sensitive to fragmentation and eventual disintegration, with a corresponding decrease in viscosity of the paste.

    7.1. Vigorous mechanical agitation of a starch paste may increase the fragmentation of swollen starch granules.

8. Conditions that result in intra- and inter-molecular linkages within a starch dispersion cause gel formation.

    8.1. Starch gel formation is favored by a high amylose content (because of its tendency to retrograde); in a native starch dispersion, gelation does not occur in the absence of amylose.

D. Carbohydrates - Cellulose and its role in food processing and preparation.

1. The chemical nature and physical structure of cellulose molecules give this component of plant materials a significant role in determining the texture of native products and their response to processing and preparation techniques.

2. A high proportion of cellulose is associated with fibrous plant tissues that resist softening by heat and mild chemical treatments.

    2.1. The resistance of cellulose to softening is probably due to its high molecular weight, linear structure with areas of intra- and inter-molecular bonding, and polymerization by the resistant β 1-4 glucosidic linkage.

    2.2. Incrustation of the cellulose with lignin tends to make plant tissues tougher and more fibrous.

E. Carbohydrates - Pectins and other complex hetero-polysaccharides and their properties of significance in food processing and preparation.

1. The chemical nature and physical structure of the molecules of pectins and many other complex hetero-polysaccharides (e.g. agar, gum arabic, carrageenan, and hemicelluloses) make these food materials useful in increasing the viscosity of liquids and, frequently, in producing a gel structure.

2. The functional properties of pectins and other complex hetero-polysaccharides are dependent on their high molecular weight, often branched structure, marked ability to absorb water, and capacity for inter-molecular bridging.

    2.1. The capacity for inter-molecular bridging of complex hetero-polysaccharides may be due to:

    - hydrogen bonding, probably predominant in high methoxyl pectin gels, containing (in addition to highly methylated polygalacturonic acid) about 65 percent sugar and having an acidity of pH 2.6 to 3.4 which reduces the negative charge on the pectin and decreases the repulsive forces on the colloid.

    - ionic bonding, predominant in low-methoxyl pectin gels, containing (in addition to polygalacturonic acid of low ester content and no sugar or as much as 50 percent) divalent ions, usually calcium or magnesium, which form bridges between carboxyl groups of different molecules.

F. Lipids - Fats and their properties of significance in food processing, preparation, and storage.

1. The chemical nature and physical properties of fats make

this food material useful as a shortening agent (i.e. in decreasing the tensile or breaking strength of a food product).

1.1. Qualities that account for the shortening power of fats (i.e. for their ability to prevent the formation of a continuous rigid structure throughout the finished product and so to increase the ease of fragmentation) and for differences among fats include:

- the insolubility of a fat in the aqueous phase of a mixture such as a batter or dough.
- the low melting point of most fats which causes them to soften or liquefy on heating.
- the fluidity or plasticity of a fat which affects the surface area it can cover and the thickness of the coating.
- the plasticity of a fat which affects its ability to incorporate air and so decreases the density of a matrix.

1.1.1. The melting point of a pure fat is largely determined by its chemical composition. A low melting point is favored by a high proportion of unsaturated fatty acid residues or a high proportion of short chain (i.e. low molecular weight) fatty acid residues.

1.1.2. Geometric and positional isomerism, the arrangement of the fatty acid residues on the glyceryl residues, and the polymorphic state of the fat crystals influence the melting point of the fat.

1.1.3. Methods of processing commonly used to alter the melting point of a fat are:

- hydrogenation, to decrease the degree of unsaturation.
- molecular rearrangement, to alter the position of the fatty acid residues on the glyceryl residues.
- control of type of isomers produced during hydrogenation.

1.1.4. The consistency of a plastic fat (i.e. of a dispersion of crystalline fat in liquid fat) is largely determined by the proportion of solid to liquid phase and the crystalline nature of the solid phase.

1.1.5. A high proportion of solid, and of the solid phase in the form of small crystals, increases the firmness of a plastic fat. The method of crystallization is a factor in determining crystal size in a fat. (See III E.)

1.1.6. The degree of plasticity of a fat is changed by a change in temperature only when the solid/liquid ratio is altered (e.g. shortenings composed of a high proportion of liquid fat combined with highly saturated fat are relatively stable to temperature changes, and also shortenings tempered to produce a varying proportion of mixed crystals with different melting points).

1.1.7. Liquid fats (i.e. fats of low melting point that are liquid at room temperature) have high spreading ability but poor air-incorporating properties. The emulsification of a liquid fat (i.e. formation of an oil/ water emulsion) decreases the surface area it can cover in a batter or dough, and the addition of appropriate chemical additives in sufficient quantity may markedly increase its ability to incorporate air.

1.2. The kind and proportion of constituent fats (i.e. of glyceryl esters of fatty acids) are important in determining the melting point and consistency and so the shortening power of commercial shortenings (i.e. natural or modified natural fats, which are mixtures of pure fats with or without intentional additives).

1.3. Surface active agents (e.g. emulsifiers added in the manufacture of plastic shortenings) favor the even distribution of a fat throughout the aqueous phase of batters and doughs and increase the stability of the dispersion.

2. Fats, because of their relatively high decomposition temperatures, provide a practical liquid cooking medium that permits the use of temperatures of 175 degrees to 200 degrees C.

2.1. The addition of surface-active agents lowers the temperature at which a fat decomposes (e.g. mono-diglycerides in hydrogenated shortenings).

- 2.2. Fats, decomposed by heat in the presence of water, are hydrolyzed to glycerol and fatty acids, and the glycerol may be dehydrated to produce acrolein, an irritant of unpleasant odor.

3. Liquid fats, because of their insolubility in water, can form oil/water emulsions.
   - 3.1. Edible oils form the dispersed phase of most food emulsions.

4. Products resulting from the oxidation of unsaturated fats (e.g. certain aldehydes and ketones) and from the hydrolysis of fats containing low molecular weight fatty acid residues (e.g. butyric acid) affect the flavor of fats in food materials, often adversely. (See V G.)

G. Lipids - Phospholipids and Lipoproteins and their properties of significance in food processing, preparation, and storage.

1. The chemical nature of phospholipids and lipoproteins gives these components of food materials important functions as surface-active agents.
   - 1.1. The presence of polar groups in the protein and phosphorus-containing residues, and of non-polar groups in the lipid and protein residues, accounts for the surface-active properties of these molecules.
   - 1.2. As surface-active agents, the phospholipids and lipoproteins are effective emulsifying agents (e.g. the lipoproteins of egg yolk) and affect the rheological properties of solid-liquid multi-phase food systems (e.g. the formation of gluten from hydrated wheat proteins).

2. Products resulting from the oxidation of phospholipids and lipoproteins affect the flavor of food materials.

3. Although the amount of phospholipid and lipoprotein present in a food material may be small, the effect on the functional properties and flavor may be highly significant (e.g. in determining the properties of the membranes of tissues and the rheological properties and flavor of various food systems).

H. Pigments and their properties of significance in food processing, preparation, and storage. (See V B.)

1. The chemical reactivity of pigments that are present in raw food materials determines the nature and extent of many color changes that occur during processing and preparation.

2. Carotenoids are relatively stable naturally-occurring plant pigments.

    2.1. Under conditions usually employed in food handling, carotenoids do not undergo chemical reactions that produce compounds of different color. (Carotenoids, because of their high degree of unsaturation, are subject to oxidation and to a trans→cis shift, brought about by heat and acid, which may cause loss of color or bleaching in some foods, e.g. freshly milled wheat flour and dehydrated carrots.)

3. Anthocyanins, chlorophylls, and anthoxanthins undergo chemical reactions that produce pigments of different color in the presence of mild acids and alkalies.

    3.1. Red forms of anthocyanins predominate in media of low pH and blue forms in media of higher pH.

    3.2. Chlorophylls are converted to pheophytins (olive-green or olive-brown in color) in acid media due to replacement of magnesium by hydrogen in the chlorophyll molecule.

    3.3. Conversion of chlorophylls to chlorophyllins (bright green in color) takes place in alkaline media due to hydrolysis of the ester groups of the molecule.

    3.4. White forms of anthoxanthin pigments predominate in an acid medium and yellow forms in alkaline media.

4. Anthocyanins and chlorophylls react with some metals to produce compounds of different color.

    4.1. Anthocyanins form salts producing characteristic color changes (e.g. an intense blue or purple with ferric iron and a purplish color with tin).

    4.2. Chlorophylls (and pheophytins) form bright green compounds with some metals (e.g. with cupric copper).

5. Carotenoids and chlorophylls are relatively insoluble in water but soluble in lipids. Anthocyanins and anthoxanthins are water soluble.

6. Myoglobin, the primary pigment of striated muscle tissue,

is red (a purplish red or, if oxygenated, a bright cherry red) when the iron of the porphyrin ring is in the reduced state (i.e. as ferrous iron).

7. Derivatives of myoglobin with the iron of the porphyrin ring in the oxidized state (i.e. as ferric iron) are brownish in color.

   7.1. Examples of conditions under which the ferrous iron of myoglobin is converted to ferric iron are:

   - low pH.
   - conditions that produce a low oxygen tension.
   - exposure to ultra-violet light.
   - contamination with microorganisms.

8. Myoglobin reacts with other compounds to produce substances that are pink.

   8.1. Examples of reactions of myoglobin that produce pink color are:

   - reaction with the nitrites used in the curing of meats and occuring as constituents of certain vegetables.
   - reactions with carbon monoxide (e.g. in charcoal broiling) and with sulfites.

   8.2. The pink pigments characteristic of cured meats are stable to heat and unstable to light.

9. Decomposition of the porphyrin ring of myoglobin causes fading of the pigment and discolorations.

10. Pigments, responsible for some changes in color that occur in food during processing, are produced from colorless components by the physical or chemical treatments employed.

    10.1. Colorless and water-soluble polyphenolic compounds react with some metallic ions (e.g. iron and cupric copper) to form dark-colored compounds.

    10.2. Polyphenolic compounds are sensitive to enzymatic oxidation and produce tan or brown pigments.

       10.2.1. Conditions that exclude air (oxygen), that reduce quinones before they can polymerize, or that inactivate enzymes minimize enzymatic browning.

10.3. Melanoidins, tan to brown polymers, are produced by complex reactions between carbonyl compounds including reducing sugars (e.g. glucose, lactose, and fructose) and amino groups (e.g. proteins of egg, flour, and milk). These reactions are called non-enzymatic browning or the Maillard reaction.

10.3.1. Formation of melanoidins is affected by the moisture level and accelerated:

- by heat (e.g. in crust browning, due either to high temperatures or long periods of heating).
- by an alkaline medium (e.g. in tan-colored cake crumb due to an excess of sodium bicarbonate or, in an angel food cake, to a high proportion of egg white and insufficient acid to lower the pH).
- by a high proportion of a reducing sugar (e.g. in the dark crust and tan-colored crumb of cake due to lactose in products reinforced with milk solids or to dextrose in products made with honey, corn sirup, or corn sugar).

10.4. Caramel, a tan or brown polymer, is produced when a sugar is decomposed by heat (i.e. by caramelization).

10.4.1. Caramelization is accelerated at high temperatures and by an alkaline pH and is increased by long periods of heating.

10.4.2. Glucose and fructose (e.g. as constituents of honey, corn sugar, or corn sirup) decompose at a lower temperature than does sucrose (i.e. can and beet sugars).

I. Intentional Chemical Additives and their properties of significance in food processing, preparation, and storage. (See III --- VIII.)

1. A large number of chemicals (non-toxic in the amounts used) are added directly to food during commercial processing and home preparation to perform some desired function.

1.1. Functions of chemical additives include:

- the improvement or stabilization of color, flavor, or texture of the finished product.

- the addition or protection of nutrients.

- an increase in the length of storage life or change in the conditions required for storage.

2. Chemical compounds retard oxidative changes in food systems through more than one type of protective mechanism.

   2.1. Examples of the use of antioxidants are:

   - addition of ascorbic acid to raw fruits to reduce quinones and thus retard oxidative browning.

   - addition of butylated hydroxyanisole (BHA) to fats and fatty foods to trap free radicals and thus break the autoxidative chain involved in rancidity development.

   - sulfuring of raw fruits before dehydration to protect ascorbic acid and also to preserve color through inhibition of oxidative enzymes.

3. Some molecules containing both polar and non-polar groups (e.g. propylene glycol and mono-diglycerides) are effective emulsifying agents because they become oriented at the interface and stabilize a water-fat dispersion.

4. Compounds that lower the surface tension of a liquid (e.g. surfactants such as sodium lauryl sulfate) serve as foaming agents.

5. Compounds that decompose (e.g. ammonium acid carbonate) or mixtures that react to produce a gas, most frequently carbon dioxide gas, are effective leavening agents in baked products.

6. Hydrophilic compounds, frequently polysaccharides (e.g. alginates and gums), are effective stabilizers of aqueous dispersions because of their ability to bind water.

7. Certain acids (e.g. acetic and citric acid) and alkalies (e.g. sodium bicarbonate) are used to alter the pH of a mixture; salts having buffering properties (e.g. sodium acetate or citrate) are used to prevent marked fluctuations in pH.

8. Compounds with a characteristic flavor (e.g. sodium chloride, amyl acetate, and cyclamates) and compounds that are essentially without flavor but enhance or

intensify existing flavors (e.g. monosodium glutamate and nucleotides) may be added to improve the flavor of a food material.

9. Compounds that react with components of a food material to form insoluble substances (e.g. calcium salts with the pectic components of plant tissues) are used as firming agents.

10. Compounds that remove chemical components from a food material (i.e. sequesterants) are used to prevent undesirable changes in the sensory properties of the finished product.

    10.1. Examples of the use of sequesterants in foods include:

    - addition of citrates and acid phosphates to evaporated milk to control the concentration of calcium ions and so prevent destabilization and aggregation of the casein.

    - addition of a chelating agent to bind metallic ions that would combine with components of the food material and produce undesirable changes in color and could catalyze lipid oxidation.

11. Many chemical compounds serve as preservatives because they hinder the growth or activity of microorganisms.

    11.1. Chemical preservatives may be fairly specific in their effectiveness (e.g. inhibit molds or yeasts and not bacteria, or inhibit certain groups or species of bacteria and not others).

    11.2. The effectiveness of chemical preservatives may be due to a physical effect (e.g. changes in the cells of the microorganisms and in the amount of water available to the organism due to the high osmotic pressure of brines and sugar sirups) or to a chemical action (e.g. the inhibitory action of benzoic acid on most microorganisms and of propionates on molds).

J. Enzymes and their role in food processing and preparation.

1. Enzymes, which are proteins, because of their chemical nature and physical conformation, are highly efficient and specific organic catalysts for a large number and variety of chemical reactions.

    1.1. The highly efficient catalytic activity of enzymes appears to depend upon the presence of active sites (i.e. of specific side chains in a particular spacial arrangement) by means of which the enzyme forms an intermediate complex with the substrate and brings reactive groups into a relationship that lowers the energy of activation for the reaction.

1.1.1. An enzyme-substrate complex probably involves a multipoint attachment in which hydrogen bonds, ionic forces, and hydrophobic bonds play a major role.

1.2. Because of the nature of enzyme-substrate interactions:

- enzyme activity is highly specific (i.e. an enzyme catalyzes only one reaction or closely related reactions that require specific chemical groups in a particular conformation).
- the rate and extent of a catalyzed reaction depend (1) upon factors that influence the chemical transfers, exchanges, and reactions involved and (2) on the stability of the enzyme.

2. Control of enzymatic action is important in food storage, processing, and preparation to limit undesired reactions (e.g. oxidative browning of raw fruit tissue and proteolysis of raw meat tissue) and to optimize desired reactions (e.g. yeast fermentation in bread dough and proteolysis during the ripening of cheese).

3. In general, increased concentration of substrate and enzyme, higher temperatures (limited by the sensitivity of enzymes to thermal inactivation), and longer time increase the rate and/or extent of an enzymatic catalyzed reaction.

3.1. Enzymes are heat labile, due to denaturation of proteins at elevated temperatures.

3.2. Enzyme inactivation is generally more rapid at higher temperatures, but the resistance to thermal inactivation and the capacity for regeneration are characteristic for each enzyme.

4. Each enzyme has an optimum pH range of activity, probably related to the degree of solubility and ionic state of the components of the system.

5. The presence of activators, usually a metal, or of coenzymes (i.e. certain organic compounds) is required for the functioning of some enzymes.

6. Metals and compounds that compete with a substrate for an active site of the enzyme, or with the enzyme for critical chemical groups of the substrate, or that react irreversibly with either, inhibit enzyme activity.

K. Water and its properties of significance in food processing and preparation.

1. Water is ubiquitous in food materials, in many being the chemical component present in largest amount (e.g. over 80 percent in meat, and over 25 percent in many baked products).

2. The chemical nature and physical structure of water give this component of food materials great significance in determining the properties of raw foods and the nature of the changes that take place during food processing and preparation. Many processes and treatments employed to alter food materials are designed to add, to remove, or to change the physical or physico-chemical state of the water present.

   2.1. The high dipole moment of its molecules makes water a good solvent for polar substances, especially of ionic solids.

      2.1.1. The resulting solutions frequently provide a medium in which chemical reactions can take place.

      2.1.2. Solutions differ from water in their physical properties. (See III D.) (Water, unless distilled, contains dissolved materials the nature of which determines whether the water is "hard" or "soft", and is a factor in determining its safety for human consumption.)

   2.2. The dissociation of water, although small, makes possible many important reactions, especially hydrolytic reactions, in food materials by providing the necessary concentrations of hydrogen and hydroxyl ions in the system.

   2.3. The potential of its molecules for hydrogen bonding favors:

      - the formation of clusters of water molecules in liquid water. (In other words, in the liquid state water exists as aggregates of molecules held by hydrogen bonds, as well as monomers and a very few hydrogen and hydroxyl ions.)

- the association of water with other components of food materials, especially with carbohydrates and proteins, to form multi-phase systems that influence the rheological properties and so the texture of many foods (e.g. viscous sols and gels). (See II, III, and V.) (Involved is the orientation of water molecules on the surface of molecules of the other food components /especially those containing carbonyl and amide groups/ and then the formation of layers of polarized water molecules on these surfaces /i.e. hydration of the food components/, sometimes joining the molecules in polymer networks.)

2.3.1. The properties of "bound" water differ from those of water monomers; for example, bound water:

  - does not act as a normal solvent or hydrating agent.
  - resists crystallization and evaporation.
  - may act as a barrier to the passage of water and solute molecules or ions and so limit the rate of diffusion (e.g. in plant or animal tissues).

(Here water is referred to as "bound water" when the molecules are immobilized in polarized multilayers at the surface of a dispersed phase or as clusters of molecules attracted by van der Waals forces to a dispersed phase, e.g. a dispersion of polysaccharide molecules.)

2.3.2. The proportion of bound to free water in the various systems of a food material or mixture is characteristic and any change in these proportions usually alters the properties of the material (e.g. its texture).

2.4. The ability of water to undergo changes in state within a readily attainable temperature range permits crystallization and vaporization of liquid water to produce changes in the texture of food materials and in their storage life.

III. Physical and Physico-chemical Systems Present in Plant and Animal Tissues and in Processed and Prepared Foods. (See II, IV, and V.)

A. Single-component, single-phase systems in food materials.

1. Relatively few food materials are pure chemical compounds existing in a single phase, i.e. in the solid, liquid or gaseous state.

2. Any food material that is a single chemical compound existing in a single phase exhibits the physical properties and responds to energy changes in the manner characteristic of the state of matter.

    2.1. Examples of solid, liquid and gaseous compounds present in foods include:

    - crystalline sucrose, sodium chloride, and potassium tartrate.
    - liquid water.
    - gaseous carbon dioxide.

    2.2. Examples of changes in physical state produced in single-component food materials as the result of an energy change include the change of:

    - crystalline sucrose to a liquid when heated.
    - liquid water to ice when heat is removed and to steam when heat is added.
    - gaseous carbon dioxide to a solid under great pressure or when heat is removed.

3. When liquids are solidified (e.g. by the removal of heat) the solid will be crystalline or amorphous depending upon the arrangement of the molecules, atoms, or ions with respect to each other as their energy level is lowered. The solid will be crystalline if the arrangement is orderly (the pattern being characteristic of the substance) and amorphous if the arrangement is random.

B. Multi-component, single-phase systems in food materials.

1. Some food materials that contain more than one chemical compound exist as homogeneous single-phase systems (i.e. as true solutions). Examples are salt brines, sugar sirups, and distilled vinegar.

2. Food materials that are true solutions exhibit the characteristic physical properties of solutions (e.g. the colligative and rheological properties). (See III D.)

3. Many heterogeneous food materials contain single-phase systems (i.e. true solutions) as one of their components. Examples include: milk, the cell sap of plant tissues and the juice of muscle tissues, and the liquid phase of batters.

4. When true solutions are components of heterogeneous food materials (e.g. of plant and animal tissues), they often do not perform or respond to manipulation in the same manner as a model system of the same composition because of the complex nature of the food material.

C. Multi-phase systems in food materials.

1. Many food systems are, or contain as significant components, multi-phase systems (i.e. emulsions, foams, gels, sols, and suspensions). Examples include:

- liquid-in-liquid systems or emulsions (e.g. mayonnaise).
- gas-in-liquid or-solid systems or foams (e.g. meringues, whipped cream, and leavened baked products).
- liquid-in-solid systems or gels (e.g. pectin jellies and gelatin gels, egg custards, rennet-milk gels, and the crumb of baked products).
- solid-in-liquid systems or sols (e.g. egg and starch thickened sauces).
- solid-in-liquid systems or suspensions (e.g. crystalline candies, frozen desserts, and plastic shortenings).

1.1. Two immiscible liquids, differing in surface tension so that one tends to form into droplets and the other to spread in thin films when a mixture of the two is agitated, will produce an emulsion. (Colloidal suspensions of semi-solid fat in an aqueous medium are often identified as emulsions.)

1.1.1. An emulsion tends to be stabilized when a surface-active substance is concentrated at the liquid/liquid interface and prevents coalescence of the dispersed phase.

1.2. A liquid of low surface tension tends to incorporate air and form a foam when beaten or shaken.

1.2.1. Foams may also be produced when a gas dissolved in a liquid expands due to the reduction of pressure or the addition of heat.

1.2.2. Foams tend to be stabilized if the continuous phase has a low vapor pressure and attains semi-solid or solid properties. Examples of stable foams are:

- egg white foams, stabilized as a result of the denaturation of the protein during beating and its coagulation when heated.
- whipped cream, stabilized by the aggregation of solid fat throughout the protein films.
- certain baked products, stabilized by the coagulated gluten and egg proteins and the gelatinized starch.

1.3. Under conditions that favor inter-molecular bonding, solid-liquid dispersions of lyophilic, linear macromolecules produce a polymer network throughout the dispersion that holds the liquid phase and form a gel. (See II A, C, and E.)

1.3.1. Energy changes that increase inter-molecular bonding increase the strength of a gel. Examples of energy changes that increase inter-molecular bonding are:

- physical treatments, such as the addition of heat to a protein dispersion.
- changes in the chemical composition, such as the addition of calcium ions to a pectin dispersion.

1.3.2. Energy changes that increase inter-molecular bonding will produce syneresis or cause precipitation of the solid phase when an increase in bonding decreases the number of sites for binding the liquid phase or decreases the size of the inter-molecular spaces that entrap liquid in the gel.

1.3.3. Conditions that prevent or decrease inter-molecular bonding may prevent gel formation or weaken or destroy a gel structure. Examples include:

- physical treatments, such as increasing the concentration of sucrose in a dispersion of wheat gluten.
- changes in the chemical composition,

such as the addition of citrates or phosphates to a dispersion of casein.

1.4. Solid-in-liquid systems produce viscous sols when the solid particles, due to their concentration or lyophilic properties, produce internal friction and cause resistance to flow.

1.5. Solid-in-liquid systems may yield a multi-phase system with solid-state properties that consists of a high proportion of solid phase in suspension in the liquid phase.

1.5.1. Multi-phase systems with solid-state properties may be produced by:

- conversion of much of the liquid to a crystalline solid at its freezing point by the removal of heat from the system (e.g. ice crystals from an ice cream or sherbet mix).
- precipitation of much of the solid from a supersaturated solution, usually by beating or seeding to initiate crystallization (e.g. sucrose crystals in a crystalline candy).

D. Colligative properties of solutions and some properties of pure liquids.

1. Water may be added to or removed from a solution by the process of osmosis.

1.1. Water will pass through a semi-permeable membrane or barrier into an aqueous solution (e.g. water into a dried fruit or vegetable tissue) or from a dilute to a more concentrated aqueous solution (e.g. fresh fruit tissue to concentrated sugar sirup or fresh vegetable tissue to concentrated brine).

1.2. Osmotic pressure, which controls diffusion, is proportional to the concentration of dissolved particles (usually molecules or ions).

2. The addition of energy in the form of heat to a pure liquid both increases the rate of evaporation and raises the temperature.

2.1. A pure liquid reaches maximum temperature at the boiling temperature; additional increments of heat will increase the rate of evaporation.

   2.2. Evaporation rate is influenced by the surface area of the liquid (e.g. greater evaporation with large area) and the degree of saturation of the vapor phase (e.g. less evaporation in a covered container) as well as by temperature.

3. The removal of energy in the form of heat from a pure liquid lowers the rate of evaporation and the temperature of the liquid until the freezing temperature is attained and the liquid begins to convert to the solid state. (The vapor pressures of the liquid and solid phases are equal.)

   3.1. At its freezing point no further decrease in temperature occurs in a pure liquid due to the removal of heat energy until the conversion of the liquid to the solid state is complete.

4. The boiling point of a liquid depends upon its vapor pressure and upon the prevailing atmospheric pressure.

   4.1. Every pure liquid has a characteristic vapor pressure and so a specific boiling point at a given atmospheric pressure.

   4.2. The presence of a dissolved substance causes the resulting solution to have a lower vapor pressure, and so a higher boiling point, than the pure solvent (e.g. sugar sirups and brines vs water).

      4.2.1. Volatile solutes are an exception since they produce solutions having a higher vapor pressure than that of the pure solvent (e.g. a solution of alcohol in water).

   4.3. The boiling point of a liquid is lowered if the pressure exerted upon it is decreased (e.g. under vacuum, at high altitudes, and when the barometric pressure is low).

   4.4. The boiling point of a liquid is raised if the atmospheric pressure is increased (e.g. in an autoclave or pressure cooker).

5. The freezing point is specific for pure liquids and is lowered by the presence of dissolved substances (e.g. sugar sirups and brines vs water). (In a solution the freezing point is related to the vapor pressure of the pure solvent in the liquid and solid states.)

6. The elevation of the boiling point and depression of the freezing point of a solution, compared with that of the pure solvent, is proportional to the concentration of dissolved particles (i.e. molecules or ions).

   6.1. At the same percentage concentration, solutes of low molecular weight (e.g. dextrose compared with sucrose) and solutes that ionize (e.g. sodium chloride compared with dextrose) provide a relatively large number of particles, and so have more effect in elevating the boiling point and depressing the freezing point of the resulting solution.

      6.1.1. The solubility of the solute in the solvent is a factor in determining the limits of boiling point elevation and freezing point depression of a solution. The maximum effect is reached when the solution is saturated. (For example, the relative insolubility of lactose in comparison with other sugars limits its effectiveness in changing the boiling or freezing point of aqueous solutions; fats have no effect since they are insoluble in water.)

      6.1.2. Because of their size, colloids (e.g. starch and proteins) in solution at a given percentage composition provide a relatively small particle concentration and so their effect on the boiling or freezing point of a solvent is negligible.

      6.1.3. The addition of energy in the form of heat to an unsaturated solution at its boiling point will produce a progressively higher concentration of solute, due to the evaporation of solvent, and a corresponding increase in the boiling temperature of the solution until saturation is attained.

   6.2. At the same molar concentration, ionizable solutes that yield a large number of ions per molecule are most effective in raising the boiling point and lowering the freezing point (e.g. aluminum sulfate compared with potassium acid tartrate, and both compared with sodium chloride).

   6.3. The concentration of a simple solution (e.g. of sirups, including candy mixtures, and of pectin jellies) can be estimated by its boiling point (e.g. ^{o}C. or ^{o}F. indicate attainment of the desired sugar concentration in a sucrose sirup).

6.4. The temperature necessary to bring a mixture to the freezing point and to maintain it in the frozen state is determined by its formula.

6.4.1. Examples of the effect of the composition of a mixture on the temperature required to freeze and maintain it in the frozen state are:

- ices and sherbets, due to their relatively high concentration of sugar, require a lower "holding temperature" than ice creams.
- ice creams have a higher melting temperature than ices of equal solids content because many of the solids present are proteins, polysaccharides, and fat rather than sugars.

E. Crystallization of pure liquids or from solution.

1. Conversion of a pure substance from the liquid to the solid state (e.g. water to ice) is accomplished by a change in energy.

2. Precipitation of a solute from solution (e.g. sucrose from a sugar sirup) is accompanied by a change in energy.

2.1. Precipitation from aqueous solutions is most commonly an exothermic reaction. (The hydration energy and lattice energy of the solute determine whether the reaction is exothermic or endothermic, or whether it neither liberates nor requires added energy as is essentially true of the crystallization of sodium chloride from aqueous solution.)

3. The conditions of crystallization significantly affect the size of the crystals formed.

3.1. The simultaneous production of many crystal nuclei, when a liquid is converted to a solid or solid is precipitated from a solution, favors the formation of small crystals.

3.1.1. Rapid precipitation of the excess solute from a supersaturated solution, often initiated by agitating or seeding the solution, produces many nuclei.

3.1.2. Slow precipitation of solute from solution, usually the result of the evaporation of solvent from a saturated solution or the decreased solubility of solute as a saturated solution cools, produces few nuclei.

3.2. Factors which favor a slow rate of crystal growth (i.e. slow arrangement of molecules, atoms, or ions on the surface of the crystal nuclei) favor large crystal size.

3.2.1. A viscous medium (e.g. a supersaturated sugar solution) or the presence of substances (e.g. milk fat or gelatin in ice creams) that interfere with the movement and orientation of molecules, atoms, or ions on the nuclei effectively retard crystal growth.

3.2.2. Agitation during crystallization serves to interfere with deposition on nuclei surfaces and so to inhibit crystal growth.

3.2.3. In systems containing crystals of different sizes, the larger crystals will tend to grow at the expense of the smaller ones because of the larger surface energy of the smaller crystals.

4. A supercooled liquid or a supersaturated solution is usually an unstable system subject to crystallization; these systems may, however, yield a relatively stable amorphous solid.

IV. Processes and Treatments Employed to Alter Food Materials.

A. Production of raw food materials.

1. Genetic stock, environmental conditions, and production practices can, within limits, change the chemical composition and physical structure of plant and animal materials.

1.1. Raw foods of plant and animal origin may be altered by means of appropriate production practices to have specific properties required or desired for particular consuming and processing uses.

B. Physical processes and chemical treatments used in food processing and preparation.

1. The processes and treatments employed to produce changes in the properties of food materials involve energy exchanges.

1.1. Examples of forms used to alter food materials are chemical, electrical, thermal, light, mechanical and sonic energy.

1.2. Any exchange of energy between a system and its environment must occur without the creation or destruction of energy. (A process that occurs spontaneously is capable of doing work and the addition of external energy is required to reverse such a process, i.e. spontaneous changes tend toward an equilibrium state and some free energy must be made available to perform the work needed to remove a system from the equilibrium state. An example is the spontaneous staling of bread and at least partial renewal on heating.)

1.3. The changes produced in food materials by manipulations involving energy exchanges are usually interrelated and are often time-sensitive.

2. Various physical processes and chemical treatments are intentionally employed to produce changes in the properties of food materials.

2.1. Modifications of the properties of food materials are made in order to:

- extend storage life.
- alter or enhance functional properties.
- enhance or change palatability.
- maximize the available nutritive value.
- improve digestibility.
- destroy pathogens or remove toxic substances.
- increase the variety and convenience of available food products.

2.2. Various physical processes are employed to alter the physical or physico-chemical nature of a food or food mixture.

2.2.1. Heat may be added or removed by conduction, convection, or radiation, and may be added by internal friction. (See IV C.) Modifications produced or accelerated by the addition of heat include melting, volatilization or sublimation, solution, hydration, gelatinization, coagulation, and an increase in the concentration of a solution (due to evaporation of solvent or greater solubility of solute); modifications produced by the removal of heat include solidification (with or without crystallization), condensation, and an increase in the concentration of a solution (due to removal of solvent by freezing).

2.2.2. Mechanical energy may be applied to a food material by shaking, stirring, beating, or whipping. Modifications in the dispersion of the components that result include emulsification, batter or dough formation (often involving the development of gluten), and sol or foam formation.

2.2.3. Pressure may be reduced to increase the rate of volatilization of the liquid component of a food material (e.g. puffing a vegetable to facilitate dehydration) or to expand a gas (e.g. aerosol whipping of cream).

2.2.4. Mechanical energy may be applied by grinding, chopping, crushing, or pounding to reduce particle size.

2.3. Various chemical treatments are employed to alter the chemical or physico-chemical nature of a food or food mixture.

2.3.1. The pH may be changed to provide hydrogen or hydroxyl ions to function as a reactant or as a catalytic agent in a desired chemical reaction (usually by addition of a weak acid or alkali or of a salt).

2.3.2. Oxygen may be introduced by the addition of air or other oxidant to produce the oxidation of certain components, or may be replaced by an inert gas to inhibit the oxidation of components.

2.3.3. Water may be added to provide a reactant that is essential in all changes involving hydrolysis, or to influence the rate of ionic reactions and other reactions that occur in solution.

2.3.4. Sugars may be added to increase browning reactions involving sugars and amino compounds, or removed by enzymatic or other treatment to inhibit these reactions.

2.3.5. Enzymes may be added to catalyze desired chemical reactions (usually by adding plant or animal materials of high potency or crude concentrates from these sources).

2.3.6. Metals or ions may be added directly, or be removed by the addition of chelating agents or of substances that alter solubility or ionization, to change the chemical nature of the food material without entailing a primary chemical reaction.

2.4. Various physical processes are commonly employed to produce changes in the chemical nature of a food or food mixture.

2.4.1. Heat may be added to produce new substances by increasing the rate of chemical reactions between certain of the components of a food material or by causing the degradation or decomposition of components. (See IV C.)

2.4.2. A food material may be exposed to radiation to produce changes in its chemical components.

2.5. Several chemical treatments are commonly employed to produce changes in the physical or physico-chemical nature of a food or food mixture.

2.5.1 The ionic environment may be changed in order to alter the electric charge, and thereby increase or decrease the degree of aggregation, of dispersed particles.

2.5.2. Chemical compounds may be combined that will react to produce a gas (e.g. sodium bicarbonate and an acid phosphate or other reagents used in chemical leavening agents).

C. Transmission of heat to or from, or production of heat in, a food or food material.

1. A change in the temperature of a food material results from the transfer of heat energy from a material of higher to one of lower temperature (i.e. by conduction, convection, or radiation); an increase in temperature may result from the conversion of another form of energy to heat (e.g. heat resulting from internal friction produced by molecular vibrations induced by high frequency electro-

magnetic waves).

2. The rate of heating or cooling a food material is influenced by the method(s) of heat transfer or production employed.

   2.1. When heat energy is transmitted by conduction (i.e. by direct contact with a material of different temperature) the rate of heating or cooling is increased by several factors including:

   - a relatively high conductivity of the materials involved in the transfer (e.g. some metals have higher conductivity than others; liquid fat is a better conductor than water; and water and steam are better conductors than air).
   - a marked differential in temperature between the materials involved in the heat transfer (e.g. between the utensil and the heating medium, such as water or fat, or the cooling medium, such as a salt-ice mixture; and between the heating or cooling medium and the food material).
   - a large surface area in relation to the total mass of food to be heated or cooled.

   2.2. When heat energy is transmitted by convection currents (i.e. by the circulation of a gaseous or liquid material) the rate of heating or cooling is influenced by such factors as:

   - the fluidity of the food mass or openness of its structure. (Movement of gaseous and liquid materials is slower in viscous than in free-flowing liquids and is impeded by the presence of solid materials.)
   - a marked temperature differential between the transmitting material and the food material.
   - the use of mechanical means to increase the movement of the gaseous or liquid material.
   - a small food mass to be heated or cooled.

   2.3. Heating by radiation (i.e. heating due to the absorption of heat waves by the surface of the material) depends upon the ability of the materials involved (utensils and foods) to absorb radiant heat energy as well as upon the amount of radiant energy available.

2.3.1. The absorption of radiant heat is greater when:

- surfaces are dull, dark, and rough rather than shiny, light, and smooth.

- the proportion of exposed surface in relation to the total food mass is large.

2.4. Heat production resulting from molecular vibrations induced by exposure to microwaves is extremely rapid and occurs simultaneously, but probably not uniformly, throughout the food mass.

2.4.1. Limitations in its use include:

- increase in heating time with increase in food mass.

- lack of surface browning and crust formation.

- inappropriateness for bulky food items.

3. The amount of heat energy required to bring about a given rise in temperature in a food material is characteristic of the material (e.g. the specific heat of water is 1.0 calorie and of milk is 0.9 calorie).

D. Control of alterations in food materials.

1. The properties characteristic of many prepared foods are dependent to a degree upon chemical reactions and physical or physico-chemical changes that occur during their preparation.

1.1. The degree of variation possible in the kind and proportion of ingredients and in manipulative proceedures used without making provision for the essential functional properties is limited for many prepared foods (i.e. to replace an ingredient or process that contributes an essential reaction or change, the substitute must provide similar functional properties).

2. When functional properties of the components are not involved, acceptable prepared foods can be obtained with considerable variation in the kind and proportion of ingredients and in manipulative procedures without making compensatory adjustments.

V. Influence of Chemical Composition and Physical and Physico-Chemical Systems of a Food on the Sensory Properties. (See II and III.)

A. Sensory qualities and palatability.

1. The chemical composition and physical and physico-chemical systems present are important determinants of such sensory qualities of a food as color, form, flavor, and texture.

   1.1. Objective methods of evaluation (e.g. chemical determination of pH or of the volatile components and physical measurement of viscosity, breaking strength, or compressibility) can provide significant information about those properties of a food that are related to its sensory characteristics. The relationship between these objective data and the palatability of a food is, however, not a simple one.

   1.2. The ultimate evaluation of food palatability is subjective and is determined by assessment by the human senses.

2. The acceptability of a specific sensory quality or combination of qualities in a food is not universal, but is related to personal and cultural standards for the particular food. (See section on Human Behavior in Relation to Food.)

3. Humans vary in their ability to perceive sensory qualities, and environmental factors (e.g. temperature and light source) can affect the perception of sensory qualities of a food.

B. Influence of the components and systems present on the color of food.

1. The inherent color of a food is determined by the spectral composition of the light reflected or transmitted by it and is due to the presence of pigments - naturally occurring, produced by chemical reactions, or added (natural or synthetic) - and to physical properties of the food that affect light absorption, reflection, or transmission.

2. Pigments, because of their chemical structure, affect the absorption of light and change the spectral composition to produce a color.

   2.1. In general, conjugated systems absorb longer wave lengths of light than comparable systems containing isolated double bonds.

2.2. Some pigments produce changes in the spectral composition of light as the result of changes in the electronic state of the molecules due to the absorption of light energy (e.g. electrons raised to a higher energy level or the delocation of π electrons).

3. The way in which a surface reflects light influences color.

3.1. Surfaces that reflect all wave lengths completely and diffusely appear white.

3.1.1. Particle size affects reflectance of light, whiteness increasing with smaller particle size and finer cellular structure. Examples of whiteness due to the reflectance of light are:

- flour and powdered sugar, due to particle size.
- fondant and shortenings, due to crystal size.
- milk, due to the colloidally dispersed components.
- beaten egg white, related to the size of the air bubbles.
- bread crumb, related to the pore size of its cellular structure.

3.2. A surface may reflect light to produce an iridescent appearance (e.g. the fibers of a slice of cooked meat).

3.3. Due to its influence on the reflectance of light, the physical structure of a baked product affects both the crumb color and the appearance of the crust (e.g. shiny or dull).

4. The color of raw fruits and vegetables is largely determined by the kind and amount of naturally-occurring pigments present: anthocyanins (red-purple-blue), carotenoids (yellow-orange-red), chlorophylls (green), and anthoxanthins (white-yellow).

4.1. Changes in color of fruits and vegetables during storage, preservation, and preparation are due:

- to the removal of pigments which decreases the intensity of the color, or

- to chemical reactions involving pigments or colorless compounds present in the raw tissues which produce new compounds having a different color.

4.1.1. Examples of color changes in fruits and vegetables include:

- loss of red color when shredded red cabbage is cooked in a large amount of water due to the solubility of anthocyanins.
- development of olive-green color in green beans cooked in an acid medium, due to conversion of chlorophyll to pheophytin.
- browning of raw apple slices exposed to the air, due to enzymatic oxidation of polyphenolic compounds present in the tissues.

4.1.2. Loss of water-soluble pigments is increased by an increase:

- in the proportion of water to product.
- in the surface area of the product (e.g. by cubing, shredding, or slicing).
- in the temperature of the water, when this increases the solubility of the pigment, or the permeability of the plant tissue, or the denaturation of the protein in any protein-pigment complex.

4.1.3. Interactions between naturally-occurring plant pigments and acids in raw fruits and vegetables are minimized so long as the semi-permeable properties of the plant tissue are maintained.

4.1.4. Any pH sensitive reaction of plant pigments that results in a color change can be minimized by employing procedures that:

- dilute the acids of the plant tissue (e.g. using a large proportion of water to product).

2

- neutralize the acids (e.g. using an alkaline cooking medium such as hard water or by the addition of sodium bicarbonate).
- favor volatilization of the plant acids (e.g. using uncovered utensils).

4.2. Discoloration of plant tissue during processing and storage may be caused by non-enzymatic browning, due to reactions between reducing sugars and amines to produce melanoidins, or to the decomposition of sugars by heat to produce colored polymers (i.e. caramel).

5. The color of raw meat is largely determined by the amount of iron-porphyrin (heme) pigments present as heme-proteins in the muscle tissue (e.g. myoglobin and derivatives).

5.1. Changes in the color of meat during storage and as the result of cooking or curing are due to reactions involving myoglobin (purplish red) that produce derivatives of a different color (e.g. bright red, tan to brown, pink, and occasionally green).

5.1.1. Examples of color changes in meat involving myoglobin are:

- development of bright red color, due to the formation of oxymyoglobin when fresh muscle is exposed to air.
- development of tan to brown color, due to the production of denatured globin hemichrome during the cooking of meat.
- development of the characteristic pink color of cured meats, due to the formation of nitroso compounds.

5.2. Fatty tissues of meat may be yellowish due to the presence of carotenoids.

6. The crumb and crust color of a baked product is largely determined by the pigments present in the ingredients and by the colored compounds produced by chemical reactions between components of the mixture that occur during mixing and baking.

6.1. The color of a baked product containing no ingredient of characteristic color (e.g. no chocolate or molasses) is largely determined by reactions involving the protein and/or carbohydrate components of the mixture (e.g. the carbonyl-amine reaction and perhaps the caramelization of sugars, and the dextrinization of starch).

6.2. The influence on the crumb color of a baked product of any anthoxanthin pigments present in the flour is largely determined by the pH of the product.

6.2.1. Ingredients may be included in the formula of a batter or dough to attain the desired pH. Examples are sour milk, sodium bicarbonate, and potassium acid tartrate.

6.3. Due to their content of carotenoid pigments, the inclusion of egg, especially egg yolks, in a formula tends to give the baked product a yellowish or creamy-white crumb. Inclusion of butter or colored margarine has a similar but less marked effect.

6.3.1. Baking conditions and the pH of the mixture do not affect the yellowish color due to the presence of carotenoids because of the relative stability of these pigments.

6.4. The pigments responsible for the characteristic color of chocolate and of molasses are pH sensitive.

6.4.1. Batters containing chocolate or molasses and also having a relatively high pH produce products of darker crumb color (e.g. molasses, dark brown; chocolate, mahogany red).

6.5. Heat treatments sufficient to burn or char produce complete oxidation of some of the carbohydrate content of a baked product to form carbon (black).

C. Influence of the components of a food on its flavor.

1. Flavor of a food results from stimulation of the recepters of taste (oral areas for salt, sweet, sour, and bitter) and the receptors of odor (nasal area), and is determined by the chemical composition of the food.

1.1. Other chemically-induced sensations such as astringency and warmth (e.g. "hot" peppers) influence the acceptability of a food as does the physical characteristic, temperature.

2. Components must be in solution to stimulate the sensory receptors of taste and volatile to stimulate the receptors

of odor.

2.1. Loss of water-soluble flavoring components during cooking is minimized by the use of a small proportion of water to product.

2.2. Loss of volatile flavoring components during cooking is minimized by the use of covered utensils.

2.3. Loss of both volatile and water-soluble flavoring components during cooking is minimized by short cooking periods.

3. For most foods, small amounts of many different compounds are necessary to produce the characteristic flavor.

4. Flavoring compounds may be naturally-occurring substances, substances produced by chemical reactions during processing, preparation, or storage or added (natural or synthetic) substances.

4.1. The flavor of raw fruits is determined largely by their content of sugars, acids, various volatile organic compounds, and polyphenolic compounds.

4.1.1. Sugar content and acidity (pH) contribute the sweet-sour taste of the fruit flavor. Sugar content usually increases and acid content usually decreases as fruits mature.

4.1.2. The characteristic flavor of a fruit is usually due to its content of aromatic compounds, including esters, alcohols, aldehydes, and other organic compounds. The kind and concentration of these compounds changes due to the metabolic processes of ripening, and as a result the flavor of raw fruits changes as they mature.

4.1.3. Some fruits are astringent due to the presence of polyphenolic compounds.

4.2. The flavor of raw vegetables is influenced by their content of sugars, acids,polyphenolic compounds, and various volatile organic compounds.

4.2.1. The sugar content usually decreases as vegetables mature due to the synthesis of starch.

4.2.2. The acidity of most vegetables is less than the sour-taste threshold of most individuals (i.e. above pH5).

4.2.3. Some vegetables are astringent due to the presence of polyphenolic compounds.

4.2.4. Volatile sulfur compounds (e.g. alliin derivatives and allyl, methyl and propyl sulfides) contribute to the characteristic flavor of vegetables of the onion family. Being water soluble and volatile, some of these compounds are removed during cooking to produce a cooked vegetable of milder flavor.

4.2.5. Sulfur-containing compounds (e.g. sinigrin and S-methyl-L-cysteine sulfoxide) and their derivatives (e.g. allyl isothiocyanate, dimethyl disulfide, and hydrogen sulfide) contribute to the characteristic flavor of brassicaceous vegetables (e.g. cabbage, cauliflower, and broccoli).

4.2.6. Volatile and soluble products of the decomposition of naturally-occurring compounds such as sinigrin are responsible for the characteristic odor and taste associated with cooked brassicaceous vegetables. Decomposition of these compounds is accelerated by enzyme action (e.g. in storage after harvest) and by heat (e.g. during cooking).

4.3. The meaty flavor characteristic of all red meats and of poultry appears to be developed during cooking from flavor precursors present in aqueous portions of lean muscle tissue.

4.3.1. A basic meat flavor common to lean portions of red meats may be associated with the free amino acids and sugars present.

4.4. The characteristic flavors of different kinds of meat (e.g. beef, lamb, pork, poultry, and fish) appear to be associated with the lipid fractions of, and related compounds present in, the fatty tissues.

4.5. The flavor of the crust of baked products is due largely to products of the carbonyl-amine browning reaction. Products of the pyrolysis of sugar (i.e. caramel) may also contribute to crust flavor.

4.6. The flavor of yeast-leavened baked products is due in part to compounds produced by chemical reactions that occur during fermentation.

4.7. A bitter or soapy taste is characteristic of baked products made from mixtures containing unneutralized sodium bicarbonate (e.g. formulas containing an inadequate amount of an acid ingredient such as cream of tartar, sour milk, or chocolate, or formulas containing no acid ingredient).

4.8. Products of the oxidation of lipids are a common cause of flavor changes in foods; rancidity has developed if the products have an unpleasant odor or taste (i.e. if they include low-molecular weight aldehydes, ketones, and fatty acids).

4.8.1. Examples of flavor changes due to lipid oxidation include:

- "oxidized" flavor of whole milk. (Milk fat may also undergo flavor changes due hydrolysis producing low-molecular weight fatty acids, e.g. butyric acid.)
- rancid flavor of shortenings and of shortened baked products that are not protected by naturally-occurring or added antioxidants.
- cold cooked-meat flavor associated with products of lipoprotein oxidation.

D. Influence of physical states and physico-chemical systems on the texture of a food.

1. Texture of a food is the complex of characteristics perceived through tactile, kinesthetic and visual sensations.

2. Important factors in determining food texture are its physical state (i.e. solid, liquid, or gas), its macroscopic structure, and the physico-chemical properties of its components.

2.1. If the solid components of a food are in crystalline form, crystal size affects texture.

2.1.1. As crystal size decreases, smoothness increases (e.g. fondant crystallized at 60° vs 100° C.) and homogeneous mixtures become firmer (e.g. shortening solidified rapidly vs gradual cooling).

2.2. When a colloidal system (e.g. sol, gel, emulsion, or foam) is present in a food, the rheological properties (i.e. flow and deformation) of the system significantly affect the textural qualities of the food, including its stability.

2.2.1. Most food sols are non-Newtonian fluids; their apparent viscosity is a measure of the internal friction produced by the dispersed phase and reflects the concentration, particle size and shape, and surface properties of this phase. Large molecules or molecular aggregates (e.g. micelles) are the usual components of this phase of a food sol (e.g. swollen starch granules and casein and albumin micelles).

2.2.2. The elasticity, plasticity, and structural stability of the continuous phase of a food gel largely determine its texture. Hyrophilic organic compounds of high molecular weight (usually capable of hydrogen and ionic bonding or bridging and sometimes of other linkages as the disulfide linkage of some proteins) are the basic components of the solid phase of most food gels (e.g. proteins, starches, pectins, and other complex polysaccharides).

2.2.3. The texture of a food emulsions depends upon the concentration and particle size of the dispersed phase and the viscosity of the continuous phase; the stability is determined by the interfacial properties. (The rigidity of an oil-in-water emulsion increases with the amount of oil emulsified due to the immobilization of the water phase as thin films around the suspended droplets.)

2.2.4. The texture of a food foam is related to the size and distribution of the gas bubbles and the rheological properties of the continuous phase. The stability of a foam is determined by the properties of the continuous phase.

3. The quantity of water, its location, and the degree of physico-chemical binding by the other components present are factors in determining the texture of many foods.

3.1. Because of the role of water, the textural quality of food is influenced by:

- the solubility and hydrophilic properties of its solid components.

- the permeability of its membranes and other barriers.

- the ionic composition of solutions within or surrounding it.

4. Turgor of plant and animal tissues is regulated by osmotic pressure when their cell membranes and other barriers are semi-permeable with respect to water (intra- and extra-cellular) and the substances dissolved in it.

5. The types of cells present and their arrangement, and the properties of the intercellular materials and of any fibrous structures present, are significant factors in determining the textural quality of raw animal and plant tissues.

6. To obtain fruit and vegetable products having the desired textural qualities, the methods of storage, of preservation and processing, and of preparation for consumption must take into account the physical and chemical changes that will be produced in the inter-cellular material, in the cellular structure of the plant tissue, and in cell turgor.

    6.1. The textural characteristics of raw fruits and vegetables are related to the types of cells (e.g. parenchyma, conducting, supporting, and protective) present and their arrangement in the plant tissue, to the nature of the intercellular material (i.e. inner lamella), and to cell turgor.

        6.1.1. A large proportion of lignin in the supporting and conducting cells of a plant tissue increases firmness and toughness of texture. Normal cooking processes are ineffective in increasing solubility or bringing about chemical changes in lignin and so in softening fibrous tissues of high lignin content.

        6.1.2. A high content of cellulose and hemicelluloses contributes to the toughness of plant tissues. Heat produces changes in hemicelluloses that decrease the toughness of plant tissues; the changes are accelerated by an alkaline pH.

        6.1.3. The solubility of the pectic substances in the intercellular material of plant tissue influences the cellular adhesion and so the firmness of a plant tissue. Protopectins are insoluble in water; pectic acids are water dispersable but certain salts (e.g. calcium pectate) are insoluble.

6.1.4. Conversion of insoluble to soluble pectic substances occurs in many plant tissues during maturation, especially in fruits, resulting in a decrease in cellular adhesion and in a softening of the tissue.

6.1.5. Conversion of insoluble to soluble pectic substances, produced by heating plant tissue, permits cell separation and results in softening of the tissue. The rate of conversion is increased in an alkaline medium (e.g. with the addition of baking soda).

6.1.6. Conversion, in the intercellular material, of the soluble to insoluble pectic substances due to the presence of certain metallic ions (e.g. calcium and magnesium in hard water and molasses and aluminum of alum), produces a firming of plant tissues.

6.1.7. Firming occurs in some plant tissues in an acid medium (e.g. carrots or cabbage cooked in water acidified with vinegar and okra in tomato-okra mixtures), probably due to increased cellular adherence and to toughening of the cell walls as the result of gel formation involving certain pectic substances and hemicelluloses. (See II E.)

6.1.8. A high degree of cell turgor contributes crispness and succulence to the texture of a plant tissue.

6.1.9. Loss of turgor caused by loss of water from the cytoplasmic fluids of plant tissue occurs:

. due to evaporation of water (e.g. wilting when stored at relatively low humidity levels).

. because of damage to the semipermeable properties of the cell membrane or other barriers (e.g. due to wilting when stored at relatively high temperatures or when heated, and to mechanical injury when bruised).

            - as the result of immersion in a liquid medium of higher osmotic pressure (e.g. shriveling when held in a concentrated brine or sirup).

7. The tenderness of meat tissue is determined largely by the relative amounts and chemical nature of the contractile (myofibrillar) and connective tissues present.

    7.1. Contractile tissue decreases in tenderness when subjected to conditions that produce denaturation and intermolecular linkages or that decrease the hydration or solubility of the myofibrillar proteins of the muscle fibers (e.g. of myosin, actin, and tropomyosin).

        7.1.1. Formation of actomyosin, a complex of actin and myosin that is stabilized by electrostatic bonds, accounts for the decreased tenderness of contracted tissue.

        7.1.2. The decreased tenderness of muscle tissue in rigormortis involves the irreversible formation of actomyosin (with the depletion of ATP) and a decrease in the solubility and hydration of the myofibrillar proteins (with a shift in the ionic balance of the tissue due to an increase in the concentration of calcium ions which results from the irreversible formation of actomyosin and a change in pH).

        7.1.3. An increase in tenderness of muscle tissue occurs during post-mortem ageing; the degree of tenderization increases with storage time and is accelerated by elevated temperatures. The mechanism is not understood but may involve enzymatic proteolysis and increased hydration of the muscle fibers due to shifts in the ionic balance.

        7.1.4. Decreasing tenderness of muscle tissue on heating results primarily from denaturation (i.e. unfolding of peptide chains) and coagulation (i.e. formation of cross-linkages producing an increasingly tighter network of protein structure) of the myofibrillar proteins.

    7.2. Increasing tenderness of muscle tissue on heating results from changes in the proteins of the connective tissue.

7.2.1. Tenderization of connective tissue is primarily due to the degradation of collagen.

7.2.2. Elastin is less susceptible to tenderization by heat than is collagen.

7.2.3. The role of the ground substance in the tenderization of connective tissue awaits clarification.

7.3. The rate and magnitude of the changes in muscle tissue on heating are influenced both by time and temperature. The time required to produce optimum tenderness in any tissue depends upon the temperature and vice versa.

7.4. Mechanical treatments (e.g. cubing, grinding, pounding, and scoring) increase the tenderness of meat tissue due to their effect on the length of the contractile fibers and the continuity of the connective tissues.

7.5. Certain proteolytic enzymes (e.g. papain, bromelin, ficin) and various fungal enzymes accelerate the hydrolysis of the connective-tissue, and sometimes the contractile, proteins of meat tissue increasing its tenderness.

7.5.1. Attainment of the desired degree of tenderness requires adequate contact of the enzyme preparation with the meat tissue and suitable temperature for enzyme action (60° - 80° C. optimum).

8. Crumb and crust, texture of a baked batter or dough is determined by:

- the physical properties of the matrix (e.g. compressibility, elasticity, and tensile or breaking strength), and
- the number and size of occluded air spaces and their distribution (i.e. as bubbles or layers and their uniformity).

8.1. The crumb texture of baked products having a foam structure (e.g. cakes, muffins, and breads) is largely determined by the thickness of the bubble walls and their physical properties.

8.1.1. Thin bubble walls that have a low tensile strength and are readily compressed produce a smooth, soft (i.e. "velvety") crumb.

8.1.2. Gas bubbles that are small to medium in size and uniformly distributed throughout the matrix produce a fine crumb texture.

8.2. The texture of baked products having a compact structure (e.g. pastry, crisp cookies, and the crust of such products as popovers and cream puffs) is largely determined by the properties of the matrix.

8.2.1. Separation of the matrix into layers produces a flaky texture.

8.2.2. A matrix of relatively high elasticity and tensile strength produces a chewy crumb or crust (e.g. stale bread crust) texture.

8.2.3. A matrix of low moisture content and low breaking strength produces either a crisp or a crumbly texture.

8.3. The kind and proportion of ingredients used, the manipulative procedures employed, and the baking conditions have a significant effect upon the crumb texture of a baked batter or dough.

8.3.1. An appropriate balance among several factors is necessary to produce the desired textural qualities, since a factor having a desirable effect on one textural quality may have a deleterious effect on another, or on another quality that is important to palatability (e.g. flavor or color).

8.3.2. Flour (wheat) and egg contribute elasticity and high tensile or breaking strength to the crumb matrix and tend to decrease its compressibility, largely due to their protein content.

8.3.3. Sugars, because of their affinity for water and their ability to raise the coagulation temperature of proteins and the gelatinization temperature of starch, help to produce a compressible crumb matrix of low tensile and breaking strength and elasticity. (Non-sugar sweeteners, such as cyclamates and saccharin, in the amounts that provide comparable sweetness produce none of the effects on the texture [or color] of baked products produced by sugars.)

8.3.4. Fats, because of their insolubility in water, their lubricating effect, and their ability to incorporate air, help to produce a compressible crumb matrix of low tensile and breaking strength and elasticity. The plasticity or consistency of the fat significantly affects the amount of air incorporated and the size and distribution of the gas bubbles in a batter, and so the texture of baked products having a foam structure.

8.3.5. Fluid and plastic shortenings with added surfactants (e.g. mono-diglycerides, glyceryl lactopalmitate, or propylene glycol monostearate) tend to produce a crumb of fine and even grain. Probably the distribution of the fat in the aqueous phase of the mixture is more uniform and the incorporated air bubbles are smaller when a surfactant is present.

8.3.6. A high proportion of fat and low proportion of water in the formula tend to produce a crisp or crumbly baked product (e.g. pastry and shortbread).

8.3.7. A chemical additive that increases the alkalinity of a mixture (e.g. sodium bicarbonate) tends to decrease the tensile or breaking strength and the elasticity of the crumb and to increase its compressibility, due largely to the increased dispersion of wheat gluten in an alkaline medium.

8.3.8. Chemical additives (i.e. leavening agents such as baking powders and ammonium bicarbonate) are used in batters and doughs to alter the physical properties of the crumb matrix and the size of the pores in the baked product. They react during manipulation and baking to produce gas (usually carbon dioxide gas) that expands existing air bubbles and thus influences the pore size of the crumb. (Carbon dioxide gas and water vapor have limited ability to initiate bubble formation in a batter.)

8.3.9. If the gas pressure is sufficient to cause excessive rupture of the original foam structure of the batter or dough, a harsh crumb, characterized by large or collapsed bubbles with thick walls, is produced.

8.3.10. Manipulative procedures (e.g. beating and kneading) that favor the development of a tenacious and elastic gluten matrix in a batter or dough increase the effect of wheat flour on textural qualities.

8.3.11. Manipulative procedures (e.g. mixing and rolling) that produce globules of fat distributed in layers throughout a dough, together with baking conditions that produce quick coagulation of the gluten, tend to produce a flaky product (e.g. puff pastry).

8.3.12. Manipulative procedures (e.g. mixing) that result in intimate and uniform distribution of the fat throughout a dough and, to a lesser degree, baking conditions that result in slow coagulation of the gluten tend to produce a mealy baked product (e.g. shortbread).

8.3.13. Baking conditions (i.e. the rate and extent of heating) influence the time and extent of coagulation of the proteins of flour and egg and so influence their effect on textural qualities.

8.4. Storage conditions that favor retrogradation of the starch in a baked product cause a decrease in crumb elasticity and compressibility.

8.4.1. Staling, maximum at about 0° C. and retarded at temperatures above 60° C. and below 0° C., tends to increase with storage time.

VI. Potentially Hazardous Substances in Food Materials and Their Control.

A. Types of hazardous substances that limit the usefulness of foods in human diets.

1. Chemical compounds that are poisonous may be inherent in food materials or introduced by contamination during production, storage, processing, and service.

2. Certain microorganisms may contaminate food materials.

3. Certain parasites may be ingested with food materials.

B. Poisonous substances in food materials.

1. Toxic compounds, produced by their metabolic processes, occur naturally in hazardous amounts in some plant and animal food materials.

1.1. Examples of toxic compounds that occur in plant and animal foods include:

  - cyanogens in certain beans.
  - solanin in "green" potatoes.
  - neurotoxins in various species of fish.
  - alkaloids in some mushrooms.

2. Toxic radionuclides, usually resulting from atomic fission, may contaminate food materials.

2.1. Plant materials may be contaminated with radionuclides due to uptake from contaminated soil or surface contamination from fallout.

2.2. Animal tissues or products (e.g. milk) may be contaminated with radionuclides due to consumption of contaminated plant materials by animals.

3. A variety of substances, introduced into food materials "by accident", may be poisonous at the level introduced.

3.1. Poisonous substances that may be introduced into food materials include:

  - fungicides, germicides, herbicides, pesticides, antibiotics, and various additives used in food production, processing and preservation. (Permitted levels of some of these substances which are considered safe have been established by government regulatory agencies.)
  - metals such as antimony (in grey enamelware), cadmium (in plated materials), copper (if oxidized), and zinc (in galvanized iron) from processing equipment and storage containers.
  - poisonous chemicals mistaken for a food material (e.g. certain rat poisons).

4. Toxic substances produced by pathogenic organisms (e.g. certain bacteria) or fungi (e.g. certain molds) during the production and handling of food materials may be present at a level to cause food poisoning.

4.1. Examples of food poisoning due to toxic substances produced by microorganisms are:

  - botulism produced by a bacterial toxin found in inadequately processed canned meats and "non-acid" vegetables and in some vacuum-packed products (e.g. vacuum-packed smoked fish).

- Staphyloccus food poisoning caused by the toxin produced by S. aureus, a widely distributed bacterium that grows readily on many food materials, especially on those rich in protein.
- aflatoxin poisoning caused by toxins produced by certain strains of Aspergillus (recently identified in animal feeds made of moldy peanuts).

5. For most toxic substances there is an intake level below which no detectable deleterious effects occurs.

C. Infectious microorganisms and parasites in food materials.

1. Certain diseases caused by organisms transmitted by the food supply are:

   - amoebic dysentery caused by certain protozoa, especially prevalent in tropical regions.
   - viral diseases caused by virus infections (e.g. hepatitis).
   - diseases produced by a bacterial infection (e.g. brucellosis, salmonellosis, septic sore throat, tuberculosis, typhoid fever, and tularemia).
   - parasitic infections such as trichinosis, caused by Trichinella infection of pork, and infection by tapeworms.

D. Control of hazardous substances in food materials.

1. Safety of the food supply depends upon avoidance of contamination by hazardous substances at all stages from production to consumption.

   1.1. Methods of avoiding contamination of food materials with harmful substances include:

   - high standards of cleanliness for all handlers, equipment, and utensils.
   - minimum handling and manipulation.

   1.2. Semi-prepared and prepared foods have greater potential as carriers of hazardous substances than the original supplies due to opportunity for contamination during contact with people and equipment, from exposure to air, and from contaminated water supplies.

1.3. Protein-rich foods and foods of relatively high pH require special care as they provide a good media for the growth of organisms.

2. Safety of a food supply is maintained by preventing the production of large amounts of toxins and infectious materials in food materials (i.e. by creating environmental conditions unfavorable to the multiplication of any potentially hazardous organisms that may be present).

   2.1. Methods of preventing an increase in the level of toxic or infectious materials in a food include:

   - control of temperature during food storage, preparation, and service. (See IV C.)
   - limitation of time (additive, not necessarily continuous) that food remains within the "danger zone" (i.e. temperature range favoring most active multiplication).
   - provision of chemical media that inhibit the multiplication of organisms.

   2.2. Present knowledge suggests that most active multiplication of microorganisms occurs at temperatures between 45° - 140° F.

   2.3. Present knowledge suggests that the total time a food remains in the "danger zone" be no more than four hours, preferably no more than two hours.

   2.4. The environmental conditions that inhibit multiplication vary for different organisms and include such factors as moisture level, pH, osmotic pressure, supply of oxygen and other essential nutrients, and presence of inhibitors.

3. Safety of food supply may be obtained by the destruction of pathogenic microorganisms or parasites and the removal, alteration, or dilution of any hazardous substances present in the food materials.

   3.1. Measures for increasing the safety of the food supply include:

   - heat pasteurization of milk to remove pathogenic bacteria.

- storage of pork at below freezing temperatures to destroy Trichinella larvae.

- heat denaturation of the toxins produced by C. botulinum. (This does not destroy viable organisms which are still capable of producing additional toxin.)

- restriction of levels of contamination with pesticides, etc. within legal tolerances.

4. Through legislation and regulatory activities federal, state and municipal agencies provide consumer protection from an unsafe food supply.

5. Continuous testing of procedures used and substances added in providing an adequate and convenient food supply is necessary to minimize the level of hazardous substances present in food materials.

VII. Processes and Treatments Used to Extend the Storage Life of Food Materials.

A. Control of enzyme-catalyzed reactions. (See II J.)

1. Enzymes catalyze many reactions which occur naturally in food materials that limit the storage life of foods.

1.1. Examples of enzymes that hasten changes in food materials include:

- enzymes important to the changes in texture and flavor during the ripening of fruits and the maturation of vegetables.

- enzymes having a role in the post mortem aging of meats.

- enzymes that catalyze the oxidation of food components such as the fat of milk.

2. Successful preservation of many food materials requires control of the enzyme systems that hasten spoilage of the food.

2.1. Control methods used to retard or prevent enzymatic reactions in food include:

- heating to inactivate the enzymes (e.g. blanching vegetables before freezing).

- providing an environment that prevents the destructive reactions (e.g. addition of antioxidants to control darkening of fruits and flavor changes in fats and altering the pH of the media).

B. Control of microbial decomposition.

1. Multiplication of microorganisms frequently makes a food material unsafe or unacceptable for human consumption.*

1.1. Examples of microorganisms whose growth causes food spoilage are:

- microorganisms that produce toxic substances or infections. (See VI B and C.)

- microorganisms that produce undesirable changes in appearance (e.g. mold growth), in texture (e.g. soft rot in fruits and vegetables), or in flavor (e.g. souring of milk).

2. Successful preservation of food materials contaminated with spoilage microorganisms requires destruction of the microorganisms or inhibition of their multiplication.

2.1. The treatment required to inhibit or destroy microorganisms varies for the kind of organism and the particular species of a given kind of organism.

2.1.1. Examples of differences among microorganisms of importance in their control include:

- yeasts and molds are less sensitive to destruction at low pH values than are bacteria.

- molds are more tolerant of a low moisture level than are bacteria or yeasts.

- the spores of yeasts and bacteria are more resistant to destruction than are vegetative cells.

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*Note: (The controlled multiplication of certain microorganisms is used to produce desired changes in some food materials, e.g. yeasts are used in leavening bread, producing alcohol in beverages, and producing acids in pickling; certain molds and bacteria are useful in the ripening of cheese.)

- some bacteria are aerobic and others anaerobic.
- yeasts and molds are destroyed by less vigorous heat treatments than are bacteria.
- most bacteria are most susceptible to destruction by heat at low pH values.

2.2. Treatments that are effective in inhibiting or destroying microorganisms may alter the organism itself or create an unfavorable environment.

2.2.1. Preservation by heat treatment or by radiation directly affects the organism. Mild treatments may effect pasteurization but not sterilization.

2.2.2. Freezing, drying, the addition of chemical preservatives and of antibiotics, and removal of oxygen owe their effectiveness primarily to the creation of an environment that is unfavorable to multiplication of the organism.

C. Control of undesirable chemical reactions.

1. Chemical reactions, that are related neither to enzymatic reactions nor to the multiplication of microorganisms, may occur during storage to make a food unacceptable for human consumption.

1.1. Examples of non-enzymatic, non-microbial chemical reactions that make food unacceptable are:

- carbonyl-amine reactions in dried egg solids that produce brown pigments and off-flavors and cause loss of some of the functional properties of eggs.
- oxidation of unsaturated fats that produce off-flavors.

2. Successful preservation of food materials subject to undesirable chemical reactions during storage requires the removal of components of the reaction, addition of an inhibitor, or the maintenance of conditions that minimize the reaction rate.

2.1. Examples of methods used to control undesirable chemical reactions in foods include:

- removal of glucose from egg magma before dehydration.
- addition of antioxidants to unsaturated fats.
- storage of fats and dried egg solids at relatively low temperatures and at appropriate moisture levels.

D. Control of undesirable physical and physico-chemical changes.

1. Physical changes, that are related neither to enzymatic reactions nor to the multiplication of microorganisms, may occur during storage to make a food unacceptable in human diets.

1.1. Examples of physical or physico-chemical changes that make food unacceptable are:

- changes in the crystalline state of the product, such as (1) graininess in a fondant or ice cream, due to the solution of small crystals and recrystallization on the larger crystals present, (2) spontaneous crystallization of an amorphous solid such as a brittle (a supersaturated sugar solution), and (3) grittiness in an ice cream, due to crystallization of relatively insoluble lactose, or in grape jelly, due to crystallization of potassium acid tartrate, when stored at low temperatures.
- breaking of the emulsion of a mayonnaise due to freezing.
- syneresis of starch, pectin and casein gels resulting under storage conditions that produce changes in the solid phase to decrease its liquid-binding capacity.

2. Successful preservation of food materials subject to undesirable physical or physico-chemical changes during storage requires:

- the use of appropriate kinds and proportions of ingredients (including additives designed to stabilize the system) and of manipulations in the preparation of the food product.
- the use of adequate packaging to protect the food from mechanical damage and from infestation or contamination

by offensive or toxic materials, and to prevent or control direct exposure to the storage environment (e.g. to air, light, and moisture).

- the maintenance of optimum conditions of temperature, moisture, etc. during storage.

VIII. Changes in the Nutritive Value of Foods during Storage, Processing, and Preparation. (See section on Biological Aspects of Human Nutrition, especially II. Significance of Nutrients in Meeting Biological Needs.)

A. Enhancement of nutritive value.

1. The nutritive value of a food may be enhanced during processing:

   - by increasing the availability of a nutrient for assimilation by the body.
   - by enrichment with nutrients (e.g. intentional addition of certain vitamins, minerals, and amino acids).
   - by the deposit or transfer of nutrients from equipment (e.g. iron) or the cooking medium (e.g. calcium from hard water or sodium from added salt).

B. Lowering of nutritive value.

1. The nutritive value of a food may be decreased by the removal of nutrients during processing and preparation by mechanical means and by solution.

1.1. Examples of the loss of nutrients as the result of mechanical treatments are:

   - removal of minerals and vitamins present in the bran and germ of cereals during refining.
   - removal of vitamin A from milk in the production of skimmilk and of calcium in the manufacture of certain soft-curd milks.

1.2. Water-soluble nutrients (e.g. ascorbic acid, the B-vitamins, sugars, and certain minerals) are lost to the aqueous medium during heating.

1.2.1. The extent of loss of water-soluble nutrients increases:

   - as the proportion of water to food is increased.

- as the amount of exposed surface of the food material is increased (e.g. by dicing or shredding vegetables).
- as water-resistant tissues (e.g. skin of potatoes) are removed or are altered to increase their permeability.
- to a lesser degree, as the time of cooking (of contact) is lengthened.

2. The nutritive value of a food may be decreased during processing, preparation and storage due to reactions that produce chemical changes in a nutrient which alter its nutritional properties.

2.1. Various nutrients (e.g. ascorbic acid) may lose their potency due to oxidation.

2.1.1. Nutrient loss due to oxidation is increased:

- by exposure to oxygen (e.g. by storage in air or by packaging in a vapor-transmitting material, by increasing the amount of exposed surface, and by extended exposure or storage periods).
- by conditions that accelerate the oxidation reactions (e.g. the presence of oxidases under conditions of temperature, pH, etc. that favor their catalytic activity, by the absence of antioxidants, and by the temperature and time of exposure, e.g. a short exposure at a high temperature may be less destructive than a longer exposure at a lower temperature).

2.2. Proteins may be lowered in biological value by chemical reactions that decrease the availability of essential amino acids (e.g. by the non-enzymatic browning of a food material as the result of heat treatments in processing and preparation or by the conditions of storage including moisture level, temperature, and time).

2.3. Hydrogenated fats may have a lowered nutritive value due to an increase in the degree of saturation and to the production of isomers.

BIOLOGICAL ASPECTS OF HUMAN NUTRITION

This section of the statement of concepts and generalizations is concerned with normal nutritional needs by presumably healthy individuals, and does not consider the special needs during disease. Unfortunately, several circumstances prevented completion of the statement for this major area of the field of Foods and Nutrtion. Sub-concepts and generalizations are reasonably well developed for Parts I and II, and for the first section of part III; but for the remaining section of part III and for parts IV through V only broad concepts are indicated. Further development of this area of the field should have high priority in any future efforts related to this project.

BIOLOGICAL ASPECTS OF HUMAN NUTRITION - OUTLINE

I. Biological Needs for Nutrients.

  A. Biological nature of man.

  B. Dynamic state of all tissues.

  C. Functions and sources of nutrients.

  D. Nutrition and health.

  E. Relationships of biological needs to storage and excretion.

II. Significance of Nutrients in Meeting Biological Needs.

  A. General significance of nutrients.

  B. Carbohydrates.

  C. Lipids.

  D. Proteins.

  E. Mineral elements.

  F. Vitamins.

  G. Water.

  H. Oxygen.

III. Mechanisms through which Nutrients Meet Biological Needs.

  A. General characteristics of mechanisms.

  B. Digestion of food as preparation for absorption of nutrients.

  C. Absorption.

Concepts III D-K, IV A-D, and V A-B are listed but not developed.

BIOLOGICAL ASPECTS OF HUMAN NUTRITION

I. Human Biological Needs for Nutrients.

A. Biological nature of man.

1. Life is dependent upon nutrients (see B 1) which are supplied by food. (See also section on Food Materials.)

2. The composition and functions of the organism, its tissues and constituent cells, determine nutrient needs.

3. Man's requirements for nutrients are qualitatively similar to those of other animals and of some bacteria, but there are some marked species differences.

4. All individuals of a given species, for example man, need certain nutrients, but quantitative needs for these are individual because of such factors as genetic make up, internal or external stresses, and developmental stage.

4.1. Certain physiological states (e.g. growth, pregnancy, lactation, recovery from previous depleted states, and other stresses) increase the requirements for some or all of the nutrients.

B. Dynamic state of all tissues.

1. All activities of living cells result essentially from chemical and physical processes in which the reactants are nutrients or their derivatives. All of the chemical processes taking place in an organism constitute its metabolism.

1.1. The products of these myriad reactions function in a highly organized and delicately balanced system through which life is maintained.

1.2. A constant characteristic of this dynamic system is a continuous loss of metabolic end-products, the source of which must be replenished through nutrient intake.

2. All tissues (e.g. muscle, nerve, bone, and blood) and their constituent cells are in a dynamic state with constant interchanges but not all at the same rate.

3. Different tissues, as communities of cells making up organized complex structures differentiated from their immediate environment, have specific nutrient needs.

C. Functions and sources of nutrients.

1. Nutrients are needed for the production of chemical energy, synthesis of body tissues, and maintenance of body processes.

2. The thousands of discrete substances now recognized as transitory or permanent components of cells, and which are involved in their vital reactions, are derived from the relatively few nutrients.

3. Nutrients are supplied by foods. Individual foods vary widely in the kind and amount of nutrients which they contribute. (See VB.)

D. Nutrition and health.

1. Health is dependent on a balanced supply of nutrients; lack of any one essential nutrient, excess of certain nutrients, or imbalance among them may seriously impair health.

2. Nutrient intake is determined by hunger, appetite and food habits, all of which in turn are greatly influenced by cultural, psychological, economic and agricultural conditions. (See section on Human Behavior in Relation to Food.)

E. Relationships of biological needs to storage and excretion.

1. Many nutrients and metabolites are stored to different extents and in different kinds of body reserves of varying lability. These stores can be drawn on in times of changing internal environment (e.g. body fat as source of energy; bone as source of calcium and phosphorus in blood; liver stores of vitamins and minerals). Some nutrients are not stored in large amounts (e.g. ascorbic acid).

   1.1. Retention of certain nutrients or metabolites can occur to a deleterious degree (e.g. body fat and vitamins A and D).

   1.2. Unneeded or unwanted substances can also be retained, sometimes in toxic proportions (e.g. strontium 90 and lead).

2. Metabolism leads ultimately to excretion of nutrients or their end products (e.g. creatinine, carbon dioxide, urea, and chelates or conjugates of toxic materials). Therefore a constant need exists for a new supply of nutrients which must come from food.

II. Significance of Nutrients in Meeting Biological Needs of Man.

A. General significance of nutrients.

1. The nutrients, commonly grouped as carbohydrates, lipids, proteins, mineral elements, vitamins, and water, (and also oxygen) must be supplied from the environment for the continuance of life.

2. All major organic nutrients can undergo energy-yielding oxidations.

3. All nutrients provide the chemical components for the synthesis of necessary metabolites (e.g. tissues, hormones, enzymes, etc.).

4. Certain nutrients possess a specific molecular configuration which the body has little or no ability to synthesize. These nutrients therefore have a degree of essentiality which is not common to all nutrients.

   4.1. Vitamins and certain amino and fatty acids are in this category. (See Sections II F, D, and C.)

   4.2. The nutritive value of foods is determined by their content of these essential substances.

B. Carbohydrates.

1. Energy used to meet man's metabolic needs is initially derived from the utilization of the sun's energy in the formation of carbohydrates by plants through the process photosynthesis.

2. Carbohydrates are a main dietary source of energy and they or their intermediate metabolic products contribute to the formation of essential metabolites.

   2.1. Dietary carbohydrates are obtained in large part from plant foods whereas only small amounts are provided by animal sources (e.g. glycogen of animal tissues and lactose of milk).

   2.2. Oxidation of carbohydrates in the body yields, on the average, four kilocalories per gram.

   2.3. Lipids and proteins in plants are formed from carbohydrate metabolites. Fat can also be synthesized by man from carbohydrate.

   2.4. Compounds of carbohydrates and of substances containing nitrogen occur in various tissues (e.g. mucopolysaccharides in cartilage and skin and glycosides in nerve).

3. The structure of a carbohydrate determines its utilization by and function in the body.

   3.1. Some carbohydrates are not utilized by man but may be by other species (e.g. the utilization of cellulose by the flora of the rumen of ruminants).

   3.2. Many carbohydrates are polymers and the monosaccharide units and the linkages between them are factors in their utilization and function.

C. Lipids.

1. Dietary fats are primarily mixtures of triglycerides of fatty acids (i.e. neutral fats) and usually contain small amounts of other lipids.

2. Dietary fats are important as concentrated energy sources, as carriers of fat-soluble vitamins, as sources of certain unsaturated fatty acids and other important metabolites, and for their flavor and satiety value.

   2.1. All fats provide approximately equivalent amounts of energy to the body (approximately 9 kilocalories vs 4 kilocalories per gram from carbohydrates or proteins).

   2.2. Differences in the nutritive value of neutral fats depend on the chemical composition and structure of the component fatty acids (e.g. length of the carbon chain and number and position of double bonds).

      2.2.1. Linoleic acid appears to be an "essential fatty acid" for infants.

      2.2.2. Polyunsaturated fatty acids are implicated in blood and tissue cholesterol metabolism. Some evidence suggests that they counteract a hypercholesteremic effect of saturated fatty acids, and that this effect may be a factor in reducing incidence of heart disease.

      2.2.3. Hydrogenation of fats produces changes in the component fatty acids (e.g. more highly saturated fats, and perhaps trans isomers and shifts in double bonds from methylene to a conjugated structure). Such changes may affect nutritive value.

2.2.4. Oxidation of fats during storage and/or cooking produces changes which may alter their utilization by the body.

2.3. Certain triglycerides, cholesterol esters, and phospholipids are important constituents of cellular and sub-cellular membranes.

2.4. A number of other lipids, including higher alcohols and their compounds, cerebrosides, sterols, and phospholipids have important metabolic functions.

2.4.1. They occur in foods, but most are probably altered in digestive and absorptive processes.

2.4.2. Significant amounts are synthesized in vivo from other dietary components.

D. Proteins.

1. Dietary proteins are the ultimate source of amino acids for the synthesis of the numerous body proteins in muscular, hepatic and nervous tissue, matrix of bone, hemoglobin, antibodies, skin and hair; a source of intermediate metabolic products containing nitrogen, sulfur, and carbon that contribute to the formation of many essential metabolites; and a source of energy.

1.1. All amino acids from food proteins are utilized. Certain of them, called essential amino acids, must be supplied by food because they cannot be synthesized in the body. Others are synthesized in vivo, provided that enough nitrogen is present.

1.2. Quantitative needs exist for specific amino acids which should be present in satisfactory proportions, and also for total nitrogen.

1.3. Protein supplies on the average approximately 4 kilocalories per gram in vivo. If insufficient energy-producing food is available, protein supplies energy at the expense of any other function.

2. Proteins occur in both plant and animal tissues. Most food proteins contain many individual proteins which vary in the kind and amount of amino acids present and therefore in nutritive value.

2.1. Because of the differences in their structure and metabolic functions, various plant and animal tissues, and the same tissue from different species, differ in the type of protein they contain.

2.2. The amino acids supplied by the proteins from different foods can supplement each other to improve the amino acid balance.

E. Mineral elements.

1. All mineral elements needed by the body must be supplied by the diet.

2. Mineral elements that are important as nutrients comprise a highly diverse group and in most cases they have specialized functions.

   2.1. Important specialized functions include:

   - components in tissue structure (e.g. calcium, phosphorus, and flourine in bone).
   - components in transport systems (e.g. iron of hemoglobin in oxygen transport and of cytochrome in the electron transport system).
   - components in enzyme systems (e.g. magnesium in protein synthesis) and in hormones (e.g. iodine in thyroxin).
   - components of many metabolic processes (e.g. calcium in the clotting of blood, phosphorus in the systems of energy metabolism, and calcium, magnesium, sodium, and potassium in the irritability of muscular and nervous tissue).

3. Many mineral elements play an important role in the control of acid-base, electrolyte and water balances.

4. Interactions between or among minerals may enhance or inhibit their effectiveness and so affect the dietary intake required (e.g. copper in the utilization of iron for hemoglobin synthesis).

F. Vitamins.

1. Vitamins are essential dietary factors required in small amounts for growth and maintenance.

   1.1. Vitamins cannot be synthesized in the body (except from specific precursors in certain cases, e.g. vitamin A from carotene).

   1.1.1. Some vitamins are synthesized by bacteria in the digestive tract (e.g. vitamin K).

1.1.2. Precursors of some vitamins occur in food (e.g. carotenes which yield retinol and tryptophan which can be converted to nicotinamide. Dehydrocholesterol in blood can be transformed to vitamin D through action of ultraviolet light on the skin).

1.2. Excessive intakes of certain vitamins may cause toxicity (e.g. vitamins A and D).

1.3. The extent of storage is different for the individual vitamins, so tissue reserves of certain vitamins may be depleted sooner than others.

1.4. Certain antimetabolites are known to interfere with utilization of some vitamins (e.g. many folic acid antimetabolites are used therapeutically; also, isoniazid which is antagonistic to pyridoxine, and dicumerol, antagonistic to vitamin K).

1.5. Certain vitamins may occur in more than one form (e.g. retinol, retinal, and retinoic acid; and pyridoxine, pyridoxal, and pyridoxamine).

2. The role of each vitamin is unique, and other biological compounds cannot substitute for it. The exact manner in which certain vitamins function is not yet understood.

3. Vitamins have many and diverse vital functions in metabolism.

3.1. Water-soluble B vitamins act in coenzyme systems which catalyze essential metabolic processes, e.g.:

- energy transformation (thiamine, riboflavin, nicotinaminde, etc.).
- oxidation-reduction (riboflavin, nicotinaminde, etc.).
- decarboxylation (pyridoxine, thiamine).
- transamination (pyridoxine).
- synthesis, especially of purines and pyrimidines (folinic acid, vitamin B_{12}).
- transport of one-carbon groups (folinic acid, vitamin B_{12}).

- metabolism of acyl and acetyl groups (pantothenic acid).

3.2. Vitamin A functions as retinal as part of rhodopsin and iodopsin in the retina to produce vision in both dim and bright light.

3.3. Absorption of calcium and magnesium involves vitamin D.

3.4. Vitamin K functions in the synthesis of one of the clotting factors.

4. Generally food can supply the vitamin needs of all individuals. (The need for vitamin D for growth is an exception.)

4.1. Synthetic vitamins, as well as those occurring naturally in foods, can be utilized by the body. Their use is indicated in certain situations.

4.1.1. Therapeutic use for pharmacological effects and for supplements is valuable.

4.1.2. The increasing vitamin supplementation of food products is causing concern because of the possible cumulative effect.

G. Water.

1. Except for oxygen, an adequate source of water is the most critical need for the maintenance of life.

1.1. Water is the most abundant of all chemical compounds in the body.

1.2. Water is obtained from food and drink of all kinds, from water vapor, and from metaabolic processes. Water is an end product in the metabolism of carbohydrate, fat and protein.

1.3. The well-being of an individual depends on maintenance of water content of the body within a relatively narrow range, though the normal water content of the human body varies with a number of factors such as age, sex, fat content etc.

1.4. Dehydration can occur in illness (e.g. vomiting diarrhea, hemorrhage, diuresis, and fever), at high environmental temperatures, and during vigorous exercise.

1.5. Overhydration occurs when water exceeds the proportion of electrolytes present (e.g. excess intake of sodium-free water). Water intoxication has psychological as well as physiological effects.

2. Water is essential for the maintenance of cellular integrity, and is essential for the aqueous body fluids which serve the cells.

    2.1. Water is the medium in which solution and most metabolic reactions take place.

    2.2. Water is the transport medium for nutrients, for enzymes and hormones, oxygen, and for carbon dioxide and other waste products.

    2.3. Water is important in maintenance of body temperature.

3. Fluid volume is maintained by balance of intake, excretion, vaporization, and secretion with considerable reabsorption from the digestive tract and kidneys. It is affected by exercise, ambient temperature, fever, and electrolyte balance.

4. Excretion of water is by way of urine, feces, lungs, and skin. (See III and I.) The extent of excretion via a specific pathway varies depending on environmental temperature, exercise, metabolites to be excreted (e.g. glucose or "acetone bodies") and hormonal influences.

H. Oxygen.

1. The need for atmospheric oxygen is fundamental and lack of oxygen causes damage to body processes and tissues more quickly than the effect of any other nutrient.

2. The carbon dioxide level of the blood affects the respiration center of the brain which determines rate of breathing and therefore of oxygen inspired.

3. Alterations in tensions of oxygen and carbon dioxide outside the normal range interfere with body function.

III. Mechanisms through Which Nutrients Meet Biological Needs of Man.

A. General characteristics of mechanisms.

1. The availability of metabolites, which is dependent in part on dietary sources, is a basic determinant of metabolic processes.

2. Metabolism proceeds by specific mechanisms which permit

organized transformation of nutrients to satisfy the various needs of the body.

3. The biochemical and physiological processes involved are varied, often complex, interrelated, and interdependent and frequently meet more than one need.

    3.1. In the dynamic state of the cell, hundreds of reactions go on simultaneously and generally they are reversible reactions.

        3.1.1. Reactions do not reach equilibrium because products of the reactions are removed and new substrate is added continuously.

    3.2. Virtually all of these reactions are catalyzed by specific enzymes. (See also Section on Food Materials II J.)

        3.2.1. All enzymes are proteins.

        3.2.2. Most of these are complex enzymes (holoenzymes), i.e. protein with non-protein substances (coenzymes or prosthetic groups).

            3.2.2.1. Most water-soluble vitamins (e.g. nicotinamide, riboflavin, and thiamine) are constituents of coenzymes (e.g. nicotinamide adenine dinucleotide, flavin mononucleotide, flavin adenine dinucleotide, and thiamine pyrophosphate). (See II F 3.1.)

            3.2.2.2. Certain minerals are constituents of coenzymes (e.g. iron in cytochrome and phosphorus in thiamine pyrophosphate). Other minerals are components of enzyme systems, for example, calcium and magnesium.

        3.2.3. The activity of the enzyme depends on its conformation. Both the protein component (apoenzyme) and the coenzyme of a holoenzyme determine specificity.

    3.3. Enzyme action can be inhibited in various ways (e.g. by providing a competitive component so closely allied to a coenzyme or a substrate that it takes the place of the coenzyme or of the substrate, and by heavy metals that interfere with the function of the protein moiety).

3.3.1. Inhibition of enzyme function affords a specific and often very sensitive way of modifying body processes for therapeutic purposes. (See II F 1.4.)

3.3.2. Biological regulation of biochemical reactions is often achieved through various factors which alter enzymatic activity.

4. Cells and body fluids serve as reservoirs for a wide variety of substances, endogenous and exogenous in origin, which can be drawn on for the various body processes.

4.1. These "pools" are not discrete entities, but represent available, labile nutrients in dynamic flux, with withdrawals and additions being made constantly.

5. Most metabolic reactions take place in systems which are cyclic in nature and which frequently are interdependent.

5.1. Cycles are steady state reaction sequences coupled in such a manner that a net reaction results. Important examples include:

- tricarboxylic acid cycle, a major cycle in intermediary metabolism and the common pathway of energy metabolism.
- urea (Krebs-Henseleit) cycle, the pathway for the production of urea from arginine and ornithine.
- pentose cycle, the pathway for pentose synthesis, for reduced nicotinamide adenine dinucleotide (NADH) and reduced nicotinamide adenine dinucleotide phosphate (NADPH).

B. Digestion of food as preparation for absorption of nutrients.

1. Proteins, fats, and most carbohydrates ingested as foods must be hydrolyzed to simpler units before they can be absorbed.

1.1. Mechanical processes of chewing, vigorous churning in the stomach, and muscular action of the small intestine fragment food and mix food particles with digestive juices.

1.2. Saliva, gastric juice, pancreatic and intestinal juices, and bile provide electrolytes, enzymes, emulsifying agents, and water needed for the hydrolysis of the nutrients.

1.2.1. Proteins are digested to amino acids by the proteolytic enzymes of gastric, pancreatic and intestinal juices. Conjugated proteins require the action of additional enzymes and yield characteristic end-products.

1.2.2. Fats are usually emulsified through the action of bile salts, then hydrolyzed by lipases to a mixture of glycerol and free fatty acids and mono- and diglycerides. Other lipids require the action of additional enzymes and yield characteristic end-products.

1.2.3. Digestion of starches begins in the mouth with the action of salivary amylase and continues in the intestine through the action of pancreatic amylase.

1.2.4. Digestion of disaccharides to monosaccharides is catalyzed by the respective enzymes, maltase, sucrase, and lactase, in the intestinal mucosa.

1.2.5. Digestion of different foods proceeds at different rates.

2. Other nutrients in foods (e.g. monosaccharides, free fatty acids, free forms of vitamins, and mineral elements do not require digestion prior to absorption).

3. Some components of food are not digested by man.

3.1. Factors contributing to the indigestibility of food include the presence of chemical linkages for which man lacks a specific hydrolytic enzyme (e.g. phytate).

3.2. Factors contributing to man's failure to digest a food are:

- inadequate mechanical degradation preventing contact with digestive enzymes (e.g. tough or fibrous raw vegetables).

- hypermotility of intestine which reduces digestive time.

4. Emotions can affect digestion both by changing the motility of the digestive tract and by altering the flow of digestive fluids.

C. Absorption.

1. Absorption is the movement of products of digestion and other substances from the digestive tract into the body tissues.

    1.1. Primarily, absorption is from the small intestine, through the mucosal cells of the villi which have contact with both the lymphatic and blood circulatory systems of the body.

    1.2. To a much lesser degree and for relatively few substances, absorption also occurs from the mouth, stomach, and large intestine. Water is absorbed from the large intestine.

2. Absorption is essentially a passage of materials through cell membranes into the cellular cytoplasm. Membranes are said to be permeable to materials being absorbed, though this permeability varies in degree and with respect to individual substances.

    2.1. Cell membranes are complex, highly differentiated structures involving lipid molecules, including phospholipids and cholesterol, possibly arranged in an organized fashion between outer and inner layers of protein. Finer structural details are yet unclear, but complex polysaccharides are also associated with some membrane structures.

    2.2. Membrane permeability with respect to an individual substance may be altered (e.g. by changes in pH, or by numbers of calcium ions).

3. Processes of simple diffusion and of osmosis, and selective systems of active transport,are involved in absorption.

    3.1. Simple diffusion involves movement of substances from regions of high concentration to those of low concentration.

    3.2. Osmosis, a diffusion of water through membranes, gives rise to an osmotic pressure in cells and body fluids, and this also contributes to movement of solutes across cellular membranes.

        3.2.1. A special phenomenon related to osmotic pressure is the Gibbs-Donnan effect, which includes the electrical charges of diffusible and non-diffusible ions as an additional factor in determining their movement.

3.3. Specialized active transport systems in the mucosal cells, though not yet clearly understood, are considered to be involved in the absorption of many substances.

3.3.1. Functioning of such specialized systems would explain:

- absorption against a concentration gradient.
- low or no absorption of certain potentially toxic materials.
- the high degree of selectivity in intestinal absorption.
- the requirement of energy for absorption of some nutrients.

4. The absorptive processes for individual nutrients or groups of nutrients have unique features, of which only some are well established.

4.1. Fat absorption appears to involve movement of various hydrolytic products (e.g. glycerol, free fatty acids, monoglycerides) into the mucosal cells, micellar formation, then further hydrolysis, and resynthesis of new glycerides and phospholipids.

4.2. "Protein absorption" is primarily an absorption of free amino acids, for which an active transport mechanism(s) exists. Individual amino acids are absorbed at differing rates.

4.2.1. Relatively small quantities of di- and higher peptides may be absorbed.

4.2.2. Some absorption of intact proteins also occurs, and allergenic reactions to specific proteins are attributable to such absorption.

4.3. Carbohydrate absorption is mainly at the monosaccharide level, and an active transport system is involved. A carrier mechanism has been suggested in which the monosaccharide combines with the carrier in its movement through the cell. Phosphorylation has been implicated.

4.4. Vitamins are absorbed in ways which are generally yet unknown.

4.4.1. Fat-soluble vitamins are absorbed in processes with features similar to those for fats, though differences exist for the individual vitamins, (e.g. vitamins D and K and carotene require bile salts for absorption, but vitamins A and E apparently do not).

4.4.2. Mechanisms for absorption of water-soluble vitamins vary. Phosphorylation may be involved for some.

4.4.3. Vitamin B $_{12}$ absorption requires an intrinsic factor, a mucoprotein produced in the gastric mucosa.

4.5. Mineral absorption generally occurs in the upper part of the intestine where the contents are still acid in reaction and in which some of the minerals are more soluble. Diffusion, osmosis, and active transport are all involved in the absorption of the various minerals.

Note: The intention was to include these concepts and items under then as follows:

D. Transport.

E. Cellular utilization of transported materials. (To be developed further.)

1. A high degree of organization within the cell permits utilization of metabolites for its own structure and function and for use in other parts of the body.

1.1. Structural components and their roles.

1.2. Function of differentiated cells.

2. Structure and function are determined to a large extent by inherited genetic factors.

2.1. Genes determine which substances the cell can synthesize for itself and which it must obtain from its environment as nutrients, thus delineating the biochemical capability of the cell.

2.2. Genes control the biosynthetic steps which are reflected in nutritional patterns of the cells of the individual or the species.

3. Degradation.

- F. Biological oxidation and energy utilization.
- G. Synthesis.
  - 1. Regulation.
  - 2. Alternate pathways.
  - 3. Interrelationships.
  - 4. Adaptability.
- H. Storage.
- I. Excretion.
- J. Special mechanisms involved in major physiological processes.
  - 1. Clotting of the blood.
  - 2. Acid-base balance.
  - 3. Immunity.
  - 4. Osmotic pressure.
  - 5. "Feedback".
  - 6. Vision.
  - 7. Calcification of bone.
- K. Experimental methods for the elucidation of mechanisms.

IV. Nutrient Requirements and Standards.

- A. Methods of determining nutrient requirement.
  - 1. Man's need for energy.
    - 1.1. Basal metabolism.
    - 1.2. Total energy need.
  - 2. Man's need for other nutrients.
  - 3. Nutritional status.
- B. Minimum requirement for adults.
- C. Nutrient requirements for growth and stress.

    - D. Recommended allowances.

V. Foods as Sources of Nutrients.

    - A. Nutritional aspects of foods.
    - B. Factors affecting nutritive value of foods.

HUMAN BEHAVIOR IN RELATION TO FOOD

This section of the statement of concepts and generalizations for the field of Foods and Nutrition is essentially the contribution of one person, Dr. Marion Sweetman, currently Consultant, Department of Foods and Nutrition, University of Connecticut. The Committee has reviewed and supports its inclusion in this report. While recognition of the need to understand the factors that influence individual and group behavior in relation to food is not new, to date efforts to delineate the key ideas essential to a mastery of this area have been limited. Dr. Sweetman's familiarity with pertinent social science literature, especially literature in cultural anthropology, has provided valuable background for her contribution.

HUMAN BEHAVIOR IN RELATION TO FOOD - OUTLINE

I. Human Foodways - the uniformities and diversities of man's activities in the Getting, Selecting, Manipulating, and Eating of food.

   A. Food getting.

   B. Food selecting.

   C. Food manipulating.

   D. Eating.

II. The Origin and Development of Human Foodways.

   A. Human foodways - adaptations of a population to the environment.

   B. The evolution of human foodways - the time sequence of adaptations made by a population.

III. Individuality in Food Behavior.

   A. Individual differences in food behavior among members of a society.

IV. Food Behavior and Human Well-being.

   A. The nature of well-being as it depends on food.

   B. Food behavior, the parameters of FCP and effects on human well-being.

HUMAN BEHAVIOR IN RELATION TO FOOD

All animals must "behave"; in contrast to plants, they must move to get, select, manipulate, and eat food. Man differs from other species in the limited degree of universality in his food behavior. His activities involving food are patterned within societies but widely diverse among societies.

I. Human Foodways - the uniformities and diversities of man's activities in the Getting, Selecting, Manipulating, and Eating of food. The uniformities involve basic functions and general forms of behavior; the diversities comprise specific behavior patterns developed and transmitted within societies.

A. Food getting.

1. The priority of food in the life of man.

1.1. Food (including water) is the only material necessity common to all mankind, except oxygen which is present everywhere on the earth's surface.

1.2. Even civilized man, when deprived of food to the level of semistarvation, thinks and talks primarily of food, dreams of food, is emotionally stirred only by concerns involving food, and desires food above all else.

1.3. Food is everywhere an accompaniment or focal center of most of man's significant group experiences.

1.4. In most of the world, more time and effort are devoted to activities concerned with food than with any other need or want of everyday living.

2. The nature of human food-getting activity.

2.1. Food-getting for man, as for all other animals, is primarily activity to obtain, directly or indirectly, the primal nutrients synthesized or accumulated by chlorophyll-bearing plants.

2.2. Man's food-getting under normal conditions was probably never random searching for anything that might be considered edible.

3. The methods of human food-getting.

3.1. The primary methods of human food-getting are (1) hunting wild animals and gathering wild plant products, and (2) cultivating domesticated plants and rearing domesticated animals.

3.2. Food is distributed among members who have not participated in primary food-getting in the voluntary forms of gifts or exchanges in all societies, and in the involuntary forms of thefts and levies almost as universally.

B. Food selecting.

1. Man's species omniverousness.

1.1. Among all animal species, man has almost no rivals in omniverousness in the sense that somewhere at sometime he has probably eaten anything that he could ingest with impunity.

2. The nature of man's food selectivity.

2.1. No human individual or group customarily eats at random among all the foods available.

2.2. Acceptance ranges from high, but not exclusive, consumption to complete rejection.

2.3. The strength of food taboos, disdain for foods ordinarily fed to animals, or resistance to the unfamiliar may lead people to starve in the presence of foods in common use elsewhere.

3. Societal patterning of food selectivity.

3.1. Particular societies display relatively standardized patterns of food acceptance and rejection which differ from those of other societies.

3.2. Societies tend to pattern the amounts and combinations of foods consumed.

C. Food manipulating.

1. Man's proclivity for manipulation in relation to his foodways.

1.1. Man possesses unique manipulative and cortical capacities that interact to produce behaviors involving food which enable him to alter food materials in a great variety of ways to meet his needs and wants.

1.2. People everywhere eat very little food without previous manipulation of some kind.

2. The nature of the manipulation applied to food materials.

   2.1. Direct manipulation involves the application of energy to anything that has potential value as food; indirect manipulation involves application of energy to affect the plant or animal source.

3. Societal patterning of food manipulation.

   3.1. In different societies, foods are manipulated for many of the same basic purposes: to increase ingestibility, safety acceptability, etc., and to prolong edibility during storage.

   3.2. In spite of the uniformity of purposes for food manipulation, no two societies derive identical products from the same species.

D. Eating.

1. The nature of man's eating.

   1.1. Hungry man does not devour whatever is available regardless of time or place but tends to follow a traditional routine except under the stress of extreme hunger or starvation.

   1.2. Traditional routines affect not only the times and places for eating but also the kinds and preparation of the foods served at a particular time, the persons with whom they are eaten, the order in which they are served, and the manner of serving and transferal to the mouth.

2. The societal patterning of eating routines.

   2.1. In most societies, humans eat at the hearth near which the women and children tend to remain and where the food is prepared.

   2.2. Man appears to be more of a meal eater than a nibbler and tends to concentrate eating in at least two daily meals, but the number of additional meals or routine snacks varies widely in different societies and seems to increase as food becomes more available.

   2.3. Particular foods prepared in particular ways tend to be eaten with each meal, but these vary widely from society to society.

   2.4. Who eats with whom and the order of their serving follow local customs and represent one of the more common ways of indicating social status.

2.5. The manner of serving and the method of transferring food to the mouth are traditional within a society but differ greatly among societies.

2.6. Rituals which have religious or other significance often accompany eating but these also differ among societies.

3. The significance attached to eating together.

3.1. Almost everywhere, eating together connotes friendliness, eases communication, and establishes a mutual bond even among casual acquaintances or strangers.

3.2. Extending hospitality which involves eating together is generally a special gesture of cordiality, and guests are usually expected to eat what is offered and to acknowledge the obligation in a conventional manner according to the prevailing etiquette.

3.3. Much contemporary eating and drinking together serves not so much a need for nutrients as a desire for relaxation or the quick rapport engendered among comparative strangers whose contacts may be widely spaced in time.

4. The varying of customary eating routines.

4.1. Most societies heighten the emotional tone of some events by associating them with a change in the eating routine.

4.2. Eating routines are changed by feasting or fasting, by observing special food taboos or eating foods reserved for the occasion, by preparing foods in particular ways, by changing the time of eating and the companions with whom the food is shared, and in other ways which conform to the customs of the group.

II. The Origin and Development of Human Foodways.

A. Human foodways - adaptations of a population to the environment. (The term "adaptation" is used in the wide sense of including all regulated adjustments to the environment and for control of the environment.)

1. The interacting systems affecting foodways at a particular time.

1.1. Foodways represent adaptations involving both biological and cultural components.

        1.2. Foodways are conditioned by the ecosystem: (1) physical, (2) biotic, and (3) sociocultural aspects of the environment.

        1.3. Foodways are manifested in food patterns which are determined by the parameters (1) availability, (2) safety, (3) acceptability, and (4) nutritive quality.

    2. Effects of changes in the systems affecting foodways.

        2.1. Change in a factor in any system may stimulate new and better adaptation.

        2.2. When change in a system does not result in adaptation, well-being deteriorates and a society may perish.

B. The evolution of human foodways - the time sequence of adaptations made by a population.

    1. The nature and role of the biological and cultural components as factors in human evolution.

        1.1. Both biological and cultural components of human evolution serve the same basic function of facilitating adjustment to and control of the environment.

        1.2. These two components differ in the ways in which they are initiated and transmitted.

        1.3. Genetic change and cultural adjustments are not independent - they develop together in response to reciprocal feedback.

    2. The biological component and its primary effects on the evolution of human foodways.

        2.1. Food is a survival need and members of human populations and their primate ancestors have always displayed genetically determined variations in anatomy, physiology, and capacities for behavior which affected ability to meet that need.

            2.1.1. These genetic variations have been subjected to natural selection according to their influence on reproductive survival.

            2.1.2. Genes controlling favored variations become more numerous in the population's gene pool and therefore more likely to be transmitted.

            2.1.3. Genetic changes in a human population usually require many generations and long periods of time to become established.

2.2. Genetic changes of major significance in the evolution of human foodways have been:

- anatomical and physiological developments including accommodative-color vision, bipedalism, and expansion of the brain cortex, and
- concomitant development of behavioral capacities including improved sensory perception at a distance, manipulative skill, and unique learning, thinking and communicating abilities.

2.3. Primary genetic changes involved in the evolution of human foodways occurred during the million or more years over which man attained species identity.

2.4. The slow rate of natural genetic change makes it generally impossible to identify specific effects that are probably proceeding at present.

3. The cultural component and its primary effects on the evolution of human foodways.

3.1. Man is not endowed with genetically-determined patterns of behavior for meeting his needs for food.

3.1.1. Human foodways are largely derived from a cultural heritage communicated among members of a society and thus sociocultural in origin.

3.1.2. Sociocultural adaptations related to food differ in survival value and are therefore influenced by natural selection.

3.1.3. Sociocultural adaptations arise more frequently and are much more rapidly transmitted than adaptations resulting from natural selection.

3.1.4. Human foodways differ uniquely from those of all other species primarily because of man's superior capacity for sociocultural adaptation.

3.2. Sociocultural changes which have been of major significance in the evolution of human foodways include:

- the adoption of relatively permanent family units which permitted males to range further for food while females cared for the young through a long period of dependency.

- the association of families in groups facilitating cooperation among males in hunting large animals.

- the domestication of plants and animals giving greater stability to the food supply and sources of animal power.

- the technological revolution which applied science and inanimate sources of power to industry and agriculture.

3.3. The technological revolution has accelerated sociocultural change in Western Europe and North America (U.S. and Canada) so that the way of life and system of values of the average resident have changed more since the mid-nineteenth century than in all the preceding centuries to the time of the earliest civilizations of Mesopotamia, Egypt, and China.

3.3.1. The technological revolution has divided the world into two types of societies: the industrially developed, the "haves", and the developing, the "have-nots".

3.3.2. Within the most developed and affluent nations, pockets of poverty resemble the developing societies in their failure to share in the fruits of modernization and in their need for aid from the rest of society to initiate and carry on needed changes.

III. Individuality in Food Behavior.

A. Individual differences in food behavior among members of a society.

1. The origins of individual differences in food behavior.

1.1. The foodways of a society are modal forms of behavior permiting a wide range of variation in individual behavior.

1.2. Individual food behavior is a unique complex of innate, developmental and learned components.

2. The nature of the components determining food behavior.

2.1. A behavior or behavioral capacity can be identified as innate only by the absence of any opportunity for learning.

2.1.1. The only identifiable neonate activities related specifically to food are sucking, swallowing, and apparently-affective responses to tastes and smells: sucking may require learning in some cases.

2.1.2. Innate components of behavior are unique because (1) only identical multiple births (monozygotic twins, for example) possess identical genotypes, (2) no two neonates, including those sharing identical genotypes, have shared identical uterine environments, and (3) development begins at conception, but viable births represent a range of post-conception ages.

2.1.3. Probably a variety of innate capacities influence food behavior throughout life, but learning begins at birth, if not earlier, and makes their identification impossible.

2.2. A sequence of developmental components influences postnatal food behavior.

2.2.1. All infants exhibit developmental behaviors such as rooting, the gradual lengthening of intervals between feeding, capacity of the tongue to move soft solids to the pharnyx for swallowing, mouthing and licking of various objects, rhythmic biting movements simulating chewing, etc.

2.2.2. Individual differences are manifested in the timing and form of these developmental behaviors.

2.2.3. Such variations are probably the effects of differences in genotype, developmental stage at birth, and environment.

2.3. Learning comprises the changes in behavior that an individual makes as the result of experience, in the case of food, sociocultural experiences with people and ideas, and sensory experiences with food materials. (See section on Food Materials.)

2.3.1. Sociocultural experiences dominate the learning of food behavior because all societies attempt to pass on the traditional foodways and all children tend to imitate or model their behavior on that of others.

2.3.2. The sensory properties of food materials influence the learning of food behavior because they are the basis for the discriminations and identifications with which expectancies and preferences are associated.

2.3.3. The learned components of food behavior are never the same even among children reared in the same family.

3. The habitual nature of individual food behavior.

3.1. Individual behavior related to food takes the form of characteristic and repetitive patterns - food habits.

3.2. Habits generally dominate individual food behavior but they may be temporarily altered by situational factors of either a physiological or a psychological nature.

3.3. Most individuals are emotionally attached to their food habits and resist or are greatly disturbed by attempts to force change in them, but voluntary change, though highly variable, has altered the food habits of everyone.

4. The parameters of individual food-consumption patterns.

4.1. Food habits resemble foodways in being manifested in food-consumption patterns determined by the parameters of availability, safety, acceptability, and nutritive quality.

4.2. Individual food habits are responsible for wide variations in human well-being.

IV. Food Behavior and Human Well-being.

A. The nature of well-being as it depends on food.

1. Well-being as a complex of needs, wants, and satisfactions.

1.1. Man shares with all animals the primal motivation for eating - the reduction of the physiological discomfort deriving from the need for nutrients - hunger.

1.2. Human food behavior is influenced not only by hunger but by a multiplicity of learned values such as prevention of hunger, sensory gratification, physical and mental invigoration, and a variety of symbolic meanings - status, healing, religion, etc.

2. The parameters of Food Consumption Patterns (FCP) as limits to variation in well-being.

    2.1. The universal parameters of FCP - availability, safety, acceptability, and nutritive quality - usually in interacting combinations, are responsible for wide differences in human well-being.

        2.1.1. The biological limits to variability in human well-being as it depends on FCP are reflected in the reproductive survival of a population - a standard consistent with:

            . a high death rate before the age of reproduction.

            . a low level of health and vigor in those who survive to reproduce.

            . relative longevity for those who reproduce but with an average far below observed potentials.

        2.1.2. Probably no population or individual has ever experienced maximum well-being from its FCP in terms of all the values sought.

    2.2. Human behavior which is largely learned and changeable is involved in the functioning of the parameters of FCP with effects that are good and ill.

B. Food behavior, the parameters of FCP, and effects on human well-being.

1. Food behavior, AVAILABILITY, and human well-being.

    1.1. The availability of food as a factor in a FCP is a function of (1) the kinds and amounts of accessible food materials, (2) the number of people dependent upon them, and (3) the effectiveness with which they are distributed according to needs and wants.

    1.2. Until the present, the major persisting problem of availability of food has arisen from its uneven distribution within and among societies.

        1.2.1. Food distribution within societies takes place by reciprocal sharing (which is characteristic of families and other blood-related units), and by voluntary or involuntary redistribution (which characterizes higher levels of socio-economic organization).

1.2.2. Food distribution among countries takes the form of (1) unrestricted trade on the basis of world prices, (2) trade restricted by barriers of many kinds, and (3) concessional exchange which may be partly or wholly subsidized by the country of origin.

1.2.3. Food distribution everywhere and at all levels is accompanied by more or less waste and failure to meet individual needs.

1.3. The unparalleled growth rate of the world population is succeeding distribution as the major problem of food availability.

1.3.1. The accelerated growth rate of populations nearly everywhere is a result of decrease in death rates rather than increase in birth rates.

1.3.2. Today, most developing countries face acute food supply problems, possibly impending famines, as a result of the rate of population growth.

1.3.3. Developed countries also have difficulty in maintaining and improving well-being as they cope with current population growth, though they are not likely to face serious food shortages in the near future.

1.4. The availability of food to meet world population needs in the immediate and predictable future will depend primarily upon more effective use of food resources at both production and consumption levels.

1.4.1. Improving distribution of food at the present rate of increase in production will not meet world needs.

1.4.2. The supply of food materials can be increased by technological development of resources for production.

1.4.3. Choices at the consumer level can increase the effectiveness of utilization of food resources whenever products and procedures are accessible.

2. Food behavior, SAFETY, and human well-being. (See section on Food Materials VI.)

   2.1. The safety of a food material for man is a function of its relative freedom from substances or organisms which are harmful to him.

      2.1.1. Safety is relative because it is conditioned by the amount of a deleterious substance, the number of pathogenic organisms, and the quantity of food(s) carrying the same agent consumed in a given period.

      2.1.2. The degree of harmfulness in a particular case is affected by the individual's age, state of health, previous exposure, and other factors.

   2.2. Organisms and substances potentially harmful to man may be present in food materials as natural components of the species or as contaminants.

      2.2.1. Some species of plants and animals are inherently poisonous to man.

      2.2.2. Food contaminants potentially harmful to man include:

- microorganisms causing animal diseases to which man is susceptible.
- microorganisms causing human infections which remain viable in food materials.
- microorganisms which produce toxins in food materials.
- chemicals (more or less purified substances) which incidentally reach food materials.
- chemicals which are intentionally added to food materials.

   2.3. Man's survival has, of course, always required some capacity to cope with hazards involving food safety.

      2.3.1, Certain moreor less universal food behaviors affecting food selection and manipulation have helped insure safety (e.g. rejecting materials having strongly bitter or acid tastes, or treating them by squeezing out and discarding juices or by leaching in water; following custom in food selection; avoiding or eating sparingly of the unfamiliar; observing effects on other people or animals; diversifying food consumption; and cooking).

2.3.2. Technologically developed societies have acquired a wide range of technics for identifying naturally-harmful food materials, for removing harmful components, and for developing safe varieties by genetic selection.

2.4. The maintenance of safety in food is a complex and ever changing problem which may never be brought under complete control.

2.4.1. No one can identify food as safe on the basis of expected sensory properties or as unsafe or on the basis of unexpected or repulsive properties.

2.4.2. The public tends to equate safety with the absence of spoilage or qualities deemed esthetically repugnant.

2.4.3. Even in technologically-advanced societies, information on which to base tolerances for safe and attainable levels of potentially harmful substances may not be adequate.

2.4.4. The funds required for adequate educating and policing of all those engaged in producing and manipulating foods generally fail to increase as fast as the problems that need attention.

2.4.5. All the precautions exercised to get a safe food to the household may be undone by the ignorance or carelessness of someone who cannot be overseen by outside agencies.

3. Food behavior, ACCEPTABILITY, and human well-being.

3.1. The acceptability of a food is a function of individual perception interacting with situational factors - a response of the individual, not a property of the food.

3.1.1. An individual's perception of a food with which he is in sensory contact is fundamentally a complex of present sensory experiences and the learnings from past sensory and related sociocultural experiences.

3.1.2. Behavior characteristic of an individual's established perception of a food may be altered by situational factors (e.g. at the market such factors might include available choices, price, quality, promotional features, etc. At the table important influences include physiological and psychological states, presence or absence of distractions, range of choices, etc.).

3.2. Acceptability as a parameter of FCP affects human physiological, psychological and economic well-being.

3.2.1. Acceptability affects physiological well-being through its influence on the kinds and amounts of foods eaten.

3.2.2. Acceptability affects psychological well-being through its relationships to sensory pleasure, social accord, and the esteem fostered by self or group identity.

3.2.3. Acceptability affects economic well-being by influencing the efficiency of resource use.

3.3. Acceptability as a parameter of FCP is unique in the universality with which individuals consciously apply it as a criterion.

3.4. Modern food markets provide consumers with foods from countries both far and near in an ever-increasing variety of unfamiliar forms and mixtures.

3.5. The identification of desired palatability qualities in these markets requires such measures as informative labeling, packaging which permits sensory examination of the products, and access to unbiased sources of information adapted to consumer needs.

4. Food behavior, NUTRITIVE QUALITY, and human well-being.

4.1. The nutritive quality of a FCP is a function of the kind, amount, and balance of the utilizable nutrients it provides in relation to individual needs for achieving relevant genetic potentials.

4.1.1. Some genetic potentials, whose attainment depends in part on the nutritive quality of the FCP, involve:

- normal physical development (not maximum growth rate or final size).

- a high level of physical and mental health and vigor.

- a reproductive capacity to produce normal, healthy offspring.

- longevity associated with the degree of physical and mental health and vigor that facilitates enjoyment of living.

4.1.2. The nutritive quality of a FCP must fulfill a survival need which man has had to meet without innate food patterning and which most (but not all) humans continue to meet without knowledge of the very recently available nutritional science.

4.1.3. The human race has survived without knowledge of the nutritional basis for FCP because:

- wide variations in well-being within a population are consistent with the maintenance of numbers that define survival.

- individuals have some capacities for physiological adaptation to variation in the nutritive quality of a FCP (e.g. differential absorption according to need, substitution of one nutrient for another, accumulation of and withdrawal from body stores, adjustment of energy output, and adjustment of growth rate).

- while man was a hunter-gatherer, his generally high energy needs, his tendency to omniverousness, and the incidence of periodic scarcity stimulated acceptance of a wide variety of food materials.

- during the same period, methods of manipulation probably seldom seriously altered the nutritive quality of food materials.

- the most critical period in the life cycle - transition to adult foods - was bridged by prolonged nursing and supplementary feeding of adult foods in premasticated, partially liquified or cooked forms.

4.1.4. Evidence from prehistoric time is inadequate for assessing the nutritional status of populations, but on the basis of food customs of more recent hunter-gatherers and primitive cultivators, probably most if not all societies developed some customs which interfered with achievement of the genetic potentials possible with available foods.

4.1.5. The domestication and cultivation of plants greatly expanded and stabilized the human food supply, but the priority of meeting energy needs to relieve hunger and to stave off starvation led to over-dependence on carbohydrate-rich, protein-poor roots imbalanced with respect to amino acids, vitamins, and minerals.

4.1.6. Today, primary malnutrition in the forms of general undernutrition, general overnutrition, and nutrient imbalance prevents a large part of the world's population from achieving their nutritional potentials and condemns others to premature death.

4.1.7. Secondary malnutrition incident to physiological or psychological stress, or the result of interference with consumption, absorption, or metabolism of nutrients resulting from disease or genetic defect, is being increasingly recognized and in some cases being successfully controlled by dietary modifications.

4.2. Inspite of the degree of success man achieved in the development of appropriate FCP without scientific understanding of nutrition, factors affecting food supplies, way of life, and human values, in a rapidly changing world, make the application of this science essential both to prevent deterioration and to achieve gains in well-being beyond those which have previously been possible.

4.2.1. Contemporary man faces a world of foods in which he has far more opportunity than in the past to make choices that are significant for health and survival.

4.2.2. The sedentary nature of much modern living represents a pronounced change in the common way of life that can be partly offset in its effects by application of nutritional science.

4.2.3. Intercultural contacts now expose almost all societies to new foods and customs of eating that are often detrimental to those still following long-established customs.

4.2.4. The damaging nutritional consequences of over-reliance on plant staples in many developing countries may be averted by simple modifications formulated by nutritional experts.

4.2.5. Many who understand the potential improvement in health and vigor that can result from the application of contemporary nutritional science, want these benefits for themselves and others.

4.3. Scientific criteria of the nutritive adequacy of a FCP require knowledge of the nutritive requirements of an individual and the composition of the food materials so far as those nutrients are concerned.

4.3.1. The determination of the nutrient requirements of an individual implies the existence of criteria for the appraisal of nutritional status.

4.3.2. The combination of particular amounts of particular foods to form standardized FCP uniform in nutritive quality is possible only within limits because food materials from the same species differ widely in composition.

4.4. Practical attempts to educate and persuade people to change their FCP to improve their nutritive adequacy frequently meet with failure or only limited success.

4.4.1. Despite an appreciation of the advantages of improved nutrition, many people are deterred by conflicting values such as (1) their attachment to tradition, esthetics, fashion, unscientific beliefs, etc., (2) their assignment of higher priority to activities that have a negative effect on the potential value of a FCP, and (3) the immediacy of sensory gratifications as compared with the long-time requirement for recognizable nutritional changes to develop.

4.4.2. Some individuals find that the recommended changes in food habits produce psychological or physiological effects that interfere with their comfort or capacity to meet their life roles to such a degree that they decide to forego the possible nutritional benefits.

4.4.3. On the whole, conservatism in relation to changing food consumption has a long record of survival value for man that continues to serve the purpose of thwarting the efforts of quacks and faddists to produce changes of dubious value.

4.4.4. Concentration on population categories most vulnerable to nutritive inadequacies - pregnant women and growing children - produce the greatest rewards for efforts to improve nutritional status at present.

4.4.5. Individuals manifesting signs of poor nutritional status retain the genetic potential to respond to nutritive improvement, provided the time limit for genetic regulation of a particular trait has not expired (e.g. retardation in stature).

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This study has demonstrated the feasibility of the method of procedure proposed for the development of a statement of the conceptual framework for curricula in a specific field of subject matter, and has indicated modifications in the procedure which should increase its effectiveness.

The Guidance Committee, including specialists from different areas of the field of Foods and Nutrition for Home Economics students, served an important function in determining the scope of the field and the broad outline of the content for the conceptual framework to be developed. More extensive time for this phase of the project would probably have facilitated the next phase of the work.

The field of subject matter under investigation may have presented unusual problems because of its scope. Curricula in Foods and Nutrition in Home Economics need to provide a degree of understanding: (1) of the chemical components and physical systems present in food materials as the basis for reliable methods of processing and preparing food for consumption; (2) of the utilization of food nutrients by the body to meet its nutritional needs; (3) of the various forms of human behavior that relate to food -- some forms that are common to all societies and individuals but many that differ from society to society and among individuals within a society; and (4) of the principles of consumer economics in relation to food. The major concepts and generalizations underlying the first two aspects of the field are based to a large extent on the natural sciences -- biochemistry, organic and physical chemistry, human physiology, and microbiology, and those of the latter aspects on such social sciences as cultural anthropology, social psychology, and economics.

Members of Foods and Nutrition faculties, while having an appreciation of and some competence in the entire field, are specialists in only one area of the field. For this reason, in the present undertaking no one person could assume responsibility for the preparation of a comprehensive statement of concepts and generalizations to serve as the working document for the Guidance Committee charged with making decisions about the rejection revision, or inclusion of specific items in the conceptual framework being developed. Divided responsibility for the initial document inevitably resulted in different rates of progress in the development of the preliminary drafts of statements. Consequently the original time scheduled proved to be unrealistic.

Delegation of the preparation of an initial statement of concepts and generalizations in a given area of the field to a person with special competence in that area, however, proved to be an effective method of developing working documents. Critical review of these documents by members of the Guidance Committee resulted in refinement of some of the statements, the decision to discard some items, and suggestions for changes in organization. Suggestions for content that should be added were also made. Revision of the material in light of the suggestions of the Committee, followed by further review and revisions, resulted in preliminary drafts that the Committee was prepared to submit to specialists who had had no previous association with the project, for their comments and suggestions. It was hoped to obtain from the "outside specialists" for each item: (1) their judgment as to its relative importance (essential, desirable, questionable, or unimportant) to a mastery of this area of the field; (2) information about its inclusion in their current curricula, either in courses taught in the department of Foods and Nutrition or offered by other departments in Home Economics or by other units of the institutions; and (3) their comments concerning the accuracy and clarity of the items. Suggestions were also requested concerning additional important concepts or generalizations that should be included in the statement.

Judgments concerning the importance of the individual items and the information about their inclusion in current curricula were obtained for only two areas of the field and from a limited number of individuals in each area. Only specialists in Home Economics were asked to rate the importance of each items. These approaches seemed to provide little useful information and did not justify a quantitative treatment of the data obtained. A high proportion of the items were judged to be "essential" or "desirable" for inclusion in the conceptual framework of the areas. All reviewers indicated for most of the items that an attempt was made to develop the concept or generalization in courses included in their curricula. There was little consensus among the reviewers as to which items were of "questionable" importance or were "unimportant". Very few suggestions were made for additions that might be included in the statement. The comments concerning the wording or accuracy of the items were also few in number, but the comments which were made were most useful in the final revision of the statement. This was especially true where a reviewer was actively engaged in research relevant to a particular concept or generalization.

All areas of the field of Foods and Nutrition are closely related to at least one other academic discipline; for example, the concepts and generalizations related to FOOD MATERIALS might be similar in some respects to those basic to the conceptual framework for a program in food science and technology or a program related to one food commodity such as vegetable crops; animal and poultry nutrition and nutritional biochemistry might share basic key ideas with the BIOLOGICAL ASPECTS OF HUMAN NUTRITION; and human development and relationships, cultural anthropology, and consumption economics might have basic content in common with HUMAN BEHAVIOR IN RELATION TO FOOD. With this in mind the preliminary draft of the revised statement of concepts and generalizations related to FOOD MATERIALS was submitted to a few departments of Food Science with the request that they indicate those concepts and generalizations which were included in their curricula. Questions concerning the accuracy of any of the statements or the need for rewording were also solicited.

Without exception, the replies indicated that much of the material included in the statement on FOOD MATERIALS is also considered important to Food Science curricula. Several of the outside Food Science reviewers commented that the means by which the concepts and generalizations are developed may, however, be expected to differ in the programs for students having different objectives. Following are some of their comments:

> "We would probably tend to alter the approach and depth of coverage of various topics from the presentation made to home economics students because of the direction of our interests and the supporting course background of our students."

> "It is impossible to compare the time devoted to the various concepts in your outline with the time allotted in our courses."

> "You can appreciate that the extent of coverage and approach varies somewhat from item to item; however, you will also note that we cover most of the major areas listed."

> "It sounds like your goals and ours are very similar. I suspect that we differ with respect to the amount of emphasis placed on certain areas."

Assuming a similar finding in relation to the commonality of some of the concepts and generalizations in the other areas of Foods and Nutrition and closely related disciplines, institutions may wish to investigate the feasibility of developing courses that serve students specializing in the several related disciplines.

Evaluation of the Method of Working (Prepared by the Education Consultant, Bernadine H. Peterson)

Individuals involved in this research project undertook a major and rather formidable task. Not only did they seek to identify and develop concepts and generalizations for the entire field of Foods and Nutrition at the college level, but, as a basis for this, it was necessary first to assess the scope and to identify the structure of the entire field since this had not been done previously. This assessment of scope and structure, although not made in depth, took major amounts of time at the first two meetings.

Because it was impossible to predict the time requirements for each of the activities necessary for Committee action, errors in judgment were made. For example, it would have been helpful to have permitted more time for interchange of ideas among Committee members prior to the initiation of the development of concepts and generalizations. Again, since a large share of the time available was utilized in the preparation of the statement of concepts, sub-concepts, and generalizations, the visits to institutions originally planned for the Coordinator, could be carried out on only a very limited scale. Misjudgments of this type created frustration for Committee members and Coordinators alike.

The subject matter competence of individuals appeared to be well utilized since specialists in each of the three areas represented in the final report participated in preparing the final drafts. Frequently there was contact by the Committee member with faculty associates at the institutions represented and this situation provided for breadth of ideas and for various points of view to be incorporated even in the early stages.

At the same time, this method of operating imposed major responsibility on the Coordinators who developed the preliminary work materials and assumed major responsibility for revisions. While it may be expedient to have the first drafts prepared by individual specialists, this may not always be possible. If it is done, it is important to be sure that persons working on preliminary drafts, particularly if these are to be developed initially be one individual, have a high degree of specialization in the area in which they are working and have sufficient time to devote to the project.

It should be remembered, too, that there was some need to divide into sub-groups to work on areas of special competence. None of the Committee members considered himself a specialist in all areas, even in such closely allied fields as Foods and Nutrition. The special contribution of sub-groups was the addition to or refinement of statements in the original draft. Adequate time must be allowed for the work of such sub-groups as their assignments may vary. These sub-groups did not replace the contribution of the members of the total committee who had responsibility for viewing the statements for the several areas in relation to the field as a whole.

Whenever possible and to the extent that time permitted, provision was made for incorporating ideas and opinions of a larger group of specialists than those on the project Committee. In a few cases opinions of specialists from other faculties, as well as Foods and Nutrition faculties, were obtained by the Committee. The spirit of interest, intense enthusiasm, and willingness to participate was evident among specialists contacted. At the same time, it should be recognized that there was considerable contribution of professional time beyond that which was financed. At times, requests to review materials may have resulted in an intrusion on professional or personal time. Some arrangement for monetary recompense for substantial services received would be advisable.

Because preliminary work materials were developed by individuals, objectivity of criticism might have been difficult. This problem was not noted in this group. Protection of individual viewpoints was assured and critical comments were constructive. It appeared that communication channels were open and operating when the Committee met to discuss materials. This appeared to be due to the respect and confidence individuals in the group felt for each other.

There was some feeling by Committee members that the preparation of college materials in Foods and Nutrition prior to the development of the high school materials might have been desirable. In some cases there appears to be uneven difficulty in the high school materials, and this might have been alleviated to some extent by reordering the sequence in developing materials at the two instructional levels. The high school materials did serve as a starting base for development of first drafts of the college materials, and in this way they were helpful to this Committee.

Coordinators found the check sheet, provided for use by specialists in their evaluations, of limited value. Most helpful, they felt, were the comments, suggestions, and constructive ideas for revisions written directly into the text of the reviewed materials.

This group was of necessity more concerned with content than with educational standards. As has been pointed out earlier, pressures of time did not permit extensive editing. Therefore, the reader will find instances in which some generalizations do not completely meet the criteria developed in the definition for this term. The Education Consultant agreed that in this initial effort it was more important to incorporate the important ideas from the field of Foods and Nutrition than to be precise about form when both could not be realized.

Concepts and generalizations presented here are in no way to be considered a plan for teaching or an outline for specific courses, but rather, those that curricula leading to the Bachelor's degree with a major or specialization in Foods and Nutrition should aim to develop. Individual teachers and faculties in departments of Foods and Nutrition or in other units of Home Economics, will organize courses and their sequence in relation to needs of their own students and the educational goals of their programs, using as substantive content the major key ideas identified here. It is hoped that these materials will encourage and guide teachers in setting criteria for course content beyond present practice. Revisions of content as well as of structure will be needed in line with contemporary trends and with the discovery of new knowledge in the field of Foods and Nutrition and related basic disciplines.

As the Project Director has indicated, these materials are in a sense incomplete and are to be regarded as initial efforts in identification and organization of the key ideas from Foods and Nutrition within the framework of Home Economics in higher education. The original proposal for this work did not include any plan for classroom or other means of evaluating the proposed concepts but it is recognized that only through such testing can the results finally be validated.

The major objective of the method chosen for working was to accomplish the task undertaken within the framework of time these fully committed people could give. The method has some major limitations and it is not without certain frustrations. It places heavy responsibilities on a few individuals. However, it does appear to be a feasible one. One of the real advantages appears to be that it is a method that permits subject matter groups to move into the area of curriculum structure and development without spending extended periods of time away from teaching and related responsibilities.

With the incorporation of certain changes recommended here, the method holds real promise for curriculum structuring and development. Perhaps not unimportant would be provision for an adequate assessment of the scope and identification of the structure of the entire field prior to development of statements of concepts and generalizations, and for greater opportunity for face-to-face discussion by specialists in the subject area as a basis for the revision of the initial drafts.

Conclusions and Recommendations

In the present undertaking, many of the concepts, sub-concepts, and generalizations considered basic to college or university teaching of Foods and Nutrition in Home Economics programs were identified. These are presented under three major topics: (1) FOOD MATERIALS, (2) BIOLOGICAL ASPECTS OF HUMAN NUTRITION , and (3) HUMAN BEHAVIOR IN RELATION TO FOOD. Review of the prepared statements for one section (FOOD MATERIALS) by a sampling of university faculty from the area of Food Science indicated that many of the same concepts are developed in their course offerings.

Utilization of a small committee of experts, with associated "coordinators" and with the services of an educational advisor, proved to be a feasible method for accomplishing a substantial portion of the original goal. The Coordinators were charged with the responsibility of preparing proposed statements of concepts, sub-concepts, and generalizations for review by the Committee. There were some problems associated with the procedure, i.e., sub-groups were unable to proceed at the same rate of accomplishment, and less than optimum amount of discussion by the total Committee concerning both the proposals of the Coordinators and the scope of the field was possible. Also, involvement of professional people, other than those who served as Committee members, was too limited.

The results of the work, even it its present state of development, should be useful to educators responsible for curriculum development. The results should also provide a basis for educators who wish to develop or refine the statement of concepts, They might serve as a basis for experimentation with different teaching methods and course organization. Further, the material might be used by all teachers, especially by beginning teachers of Foods and Nutrition in colleges and universities, as a means of assistance in selecting that which is pertinent and appropriate in their course offerings. Finally, the material might be used as a basis for discussion among faculty members teaching in closely related areas to ascertain whether concept development is being repetitiously duplicated in several units of the institution.

It is urgently recommended that these essentially preliminary efforts be reviewed by other groups with similar interests, with the purpose of completion, refinement, and improvement; likewise, that a mechanism be found which will permit regular updating of the statements. The resulting document so developed might be useful as an instrument for self-evaluation of Foods and Nutrition curricula. It is further recommended that substantial financial support be sought which will permit a test situation to be developed for evaluating the use of concepts and generalizations as a basis for teaching as compared with other possible methods. As a means of accomplishing work of the type undertaken here, further trial of the committee method, incorporating the improvements suggested by the present experience, would appear to be justified.

3

Appendix

DIRECTIONS FOR OUTSIDE REVIEWS

Attached is a section of the preliminary draft of a report of concepts and generalizations that are considered to be basic to instruction in food and nutrition at the college level. The total report includes sections on HUMAN NUTRITION, FOOD SCIENCE, and HUMAN BEHAVIOR IN RELATION TO FOOD. The concepts and generalizations included are believed to be central to a mastery of the field and to be ones that all curricula leading to the Bachelor's degree with a major in Foods and Nutrition should aim to develop.

Recognizing that this objective might be reached through various curricula, no specific courses or set of courses is suggested in the report. Furthermore, the report is presented as a contemporary statement which, in light of the many gaps in our present knowledge, must be under continuous review and revision. Additions and refinements are expected as the findings of research and the understandings gained through experience become available.

Before preparing the final report, the reaction of a selected group of educators who are specialists in the field of food and nutrition is desired. We are asking you to consider each item and indicate:

- how important in the total curriculum for the preparation of undergraduate majors in food and nutrition you consider the concept or generalization to be.

- whether this is an idea that you attempt to develop in the course(s) that you teach, and if not, whether you think it is developed in another course offered in your department or in another unit of the institution.

- any important concepts and generalizations in this area of the field that are not, and should be included in the report.

A form for recording this information is provided.

Please make marginal notes on the draft copy by a statement if you question its accuracy or would suggest a revision, and return this copy with the attached form.

CONCEPTS AND GENERALIZATIONS IN FOOD AND NUTRITION TO BE DEVELOPED FOR MAJORS AT THE BACHELORS LEVEL

KEY to EVALUATION FORM

I. Relative importance of the item.

Indicate by number:

1	2	3	4
unimportant	questionable	desirable	essential

II. Item is developed in courses: A offered by you; B offered by others.

Indicate by course number.

III. Concepts and generalizations to be added.

Indicate by consecutive numbers (1, 2, 3, etc.) and write in on sheet provided.

SAMPLE of COMPLETED FORM

Item	I. Relative importance	IIA. Developed in your courses	IIB. Developed in other courses	III. Concepts & generalizations to be added
A.	4	FN 100		
I.	4	FN 200		
1.	3		FN 250	
1.1	2		Psyc 100	
2.	3	FN 200		1
2.1	3	FN 200		